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To what far horizons?

He's at home in his small world. A house, a garden, a few streets, are the limits of his experience. But he's learning fast, and every day enlarges his horizon.

Like him, we are growing in experience; as the work of the International Geophysical Year goes forward, so does our knowledge of our home, the Earth. And with knowledge our achievement, too, will grow—to who can tell what far horizons?

To this end, the BP Aviation Service makes its own contribution by supplying fuel to the aircraft of today and by unceasing research for the fuels of the future.

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SPACEFLIGHT

Volume 1 **APRIL 1958** **Number 7**

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COVER

The Jupiter-C Rocket which launched Explorer I., the first American satellite, at 10.48 E.S.T. on 1958, January 31.

Editorial

In No. 5 of *Spaceflight*, published in October 1957, I wrote a short Editorial about the first Russian Sputnik, which was launched just as the issue was going to press in its final form. Now, in No. 7, I am doing the same in connection with America's "Explorer I", which has been successfully sent into space from Cape Canaveral.

All members of the British Interplanetary Society, and indeed everybody in Great Britain, will want to join in the congratulations which have been sent to the United States scientists from their colleagues all over the world. The triumph of the "Explorer" is indeed a notable one, and the research team which has made it possible has earned the highest praise. It would be invidious to single out any one scientist—but let us note that one of the leaders of the "Explorer" team is a valued Honorary Member of the British Interplanetary Society: Wernher von Braun, who had so much to do with rocket development in the now far-off days when even serious scientists regarded interplanetary travel as a fantastic dream. As we now know, the first Vanguard test satellite is also in orbit.

It is true that the "Explorer" is far less massive than the first Russian Sputniks, and it would be idle to pretend that America has yet equalled the Soviet achievement, but why should it be necessary for one nation to "catch up" with another? We should have passed this stage in our development long ago. Tremendous scientific strides have been made in both East and West, and failure to pool all this information is frankly childish. The Sputniks and Explorers, orbiting the Earth in a region far beyond national frontiers, must surely bring politicians to their senses and make them realize that war, whether hot or cold, is as out-dated as a dinosaur.

March 24, 1958. PATRICK MOORE

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U.S. Satellites (Failure and Success), Artificial Meteors and Project Farside

By FRANK POLLARD

On October 4, 1957, a Russian Sputnik "bleeped" its way, in orbit, around the planet Earth and ushered in the era of space flight. United States reaction ranged from shock, through chagrin, confusion, wonder and fear—to apathy. U.S. technical know-how had not only been threatened, it had suddenly been placed second in a major race. The grim reality of this major scientific achievement by the Russians suddenly brought the relative military positions of the U.S.S.R. and the U.S.A. into focus and the United States found itself behind. The shock was even more staggering when it was noted that as recently as thirty years ago the Russians were a scientifically backward people. The verbal din from all quarters, military, political and civilian has not yet subsided but it is clear that there must be a basic change in the United States approach to science and defence. Even with the successful launching of the U.S. satellite, the picture has not changed measurably although a crash-programme is underway in the technical fields.

Project Vanguard

The immediate reaction to Sputnik was the crash-programme and ill-fated attempt in December, 1957, to place a small test satellite into orbit using a Project Vanguard Launching Vehicle.[1]

The launching was programmed carefully and preparations for firing were accomplished. The three-stage launching vehicle[2] is a 72-ft. long missile and weighs 22,600 lb. Its shape is that of a rifle shell with a 45-in. base diameter. It is one of the first liquid propellant rockets designed to be controlled without the use of fins. Instead, the rocket engines are mounted on gimbals.

The liquid oxygen and kerosene liquid-propellant first-stage propels the entire vehicle to a 35-mile altitude at a velociety of 3,700 miles per hour. The 27,000-lb. thrust engine burns for approximately two minutes and twenty-two seconds. At this point six explosive bolts separate the first stage.

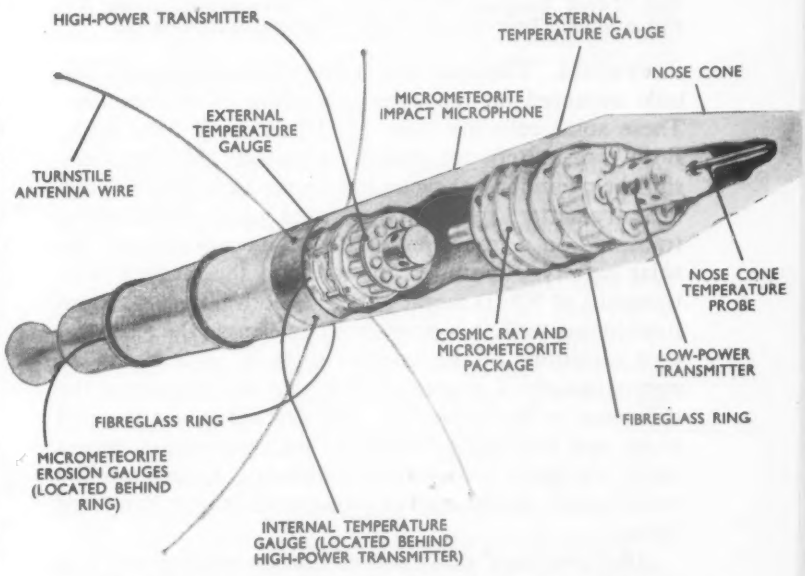
Stage II,[3] providing 7,500 lb. of thrust, lifts the vehicle to about 138 miles in altitude at a speed of 9,000 miles per hour. Second-stage propellants are white fuming nitric acid and unsymmetrical dimethyl-hydrazine fed to the engine at high pressure. Its fuel exhausted, the second stage coasts to an altitude of 300 miles. Near the peak of this coasting flight, the third stage[4] is spun at about 150 r.p.m. around its longitudinal axis in order to achieve stable third-stage flight.

The second stage houses the "brain" for the entire launching vehicle. This stage houses within its nose, which is also the nose of the composite vehicle, the third-stage rocket and the tiny satellite.[5]

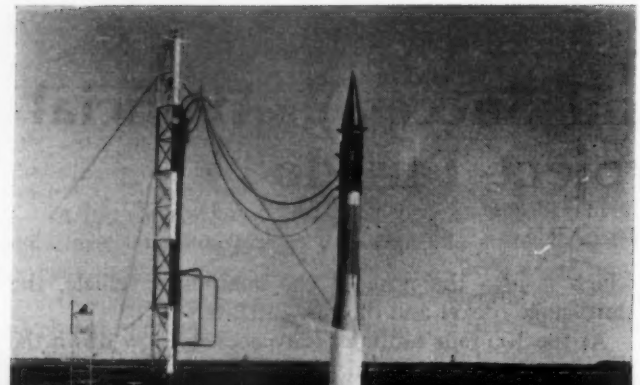
At the 300 mile altitude, retro rockets slow down the second stage and the third stage coasts free. A delay fuse ignites the solid propellant third stage and it is accelerated to a speed of 18,000 miles per hour. When this orbital velocity is reached, the satellite is separated and begins its own orbit.

The satellite is programmed to orbit the Earth every 100 minutes at approximately 300 miles altitude. Based on present estimates it could remain in orbit for about one year.

The satellite is an aluminum sphere 6·4-in. in diameter and weighing 3·5 lb. Six 12-in. dipole aluminum antennæ project from the sphere for radiating the output of two separate radio transmitters. One transmitter uses mercury batteries which provide 10 milliwatts of continuous radio frequency output for a period of two to



The scientific earth satellite put into orbit by the modified Jupiter C launching vehicle is 79 inches long and weighs 29·87 pounds. The launching was made jointly by the California Institute of Technology Jet Propulsion Laboratory and the Army Ballistic Missile Agency. In the artist's sketch above, the instrumentation in the satellite is identified. The instrument-carrying section forward is attached to the final-stage rocket in the rear so that the two orbit as one unit. Fanning out from the mid section is the antenna, made up of whip-like rods with weighted balls on the ends of the rods. The rotational spin of the satellite forces the antenna out from the satellite. Both the high-power transmitter, which radiates 60 milliwatts of radiofrequency power, and the low-power transmitter, which radiates between 10 and 20 milliwatts of power, continuously transmit the information on eight channels to ground stations. (One milliwatt is one thousandth of a watt.)



The 72-foot Vanguard Rocket in final preparations at the Air Force Missile Test Center's Cape Canaveral launching site

three weeks. The other transmitter is powered by six solar cells mounted on the exterior surface of the satellite. These solar cells are 2-in. by 2·5 in. by 1·5-in. thick. Both transmitters are pressure sensitive; the frequency shift being about 100 cycles per degree Centigrade. The mercury battery transmitter, located within the satellite, transmits on a frequency of 108·00 megacycles and the solar battery transmitter, mounted on the satellite skin, transmits at 108·03 megacycles. If both transmitters are functioning well, it is possible to determine the temperature variations of the satellite shell to an accuracy of approximately 5 degrees Centigrade by measuring the difference in the frequency. This test sphere is too small to be seen with the naked eye or with binoculars, except under the most favourable conditions. Larger satellite spheres may also be used in subsequent Project Vanguard firings.

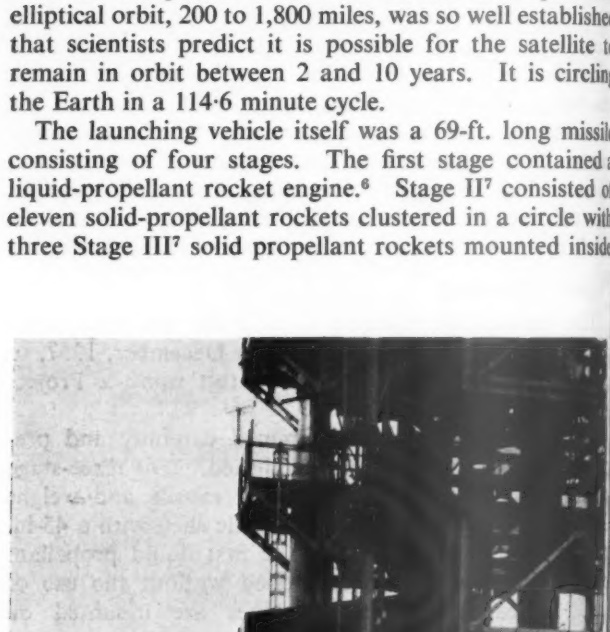
After two days' delay caused first by weather and then by technical problems, ignition occurred at 11.45 a.m., December, 6. The rocket rose slowly to approximately three feet above the launching pad, dropped back on the pad in flames and toppled over, breaking in two. Fire destroyed Stage I and Stage II. The third stage, containing the satellite, was thrown clear. The satellite transmitter continued to "bleep" although the satellite itself was damaged beyond repair. Launching pad damage was classified as "moderate" and nothing else in the area was damaged. The cause of the failure was a fuel line leak which resulted in loss of combustion chamber pressure in the first stage.

Comment was varied. Prior to the test it was stated by people in authority—not publicly—that the test would probably fail. The attempted launching was the first flight test of the second-stage rocket engine as well as the first flight test of the composite rocket vehicle. The second attempt to launch a Project Vanguard satellite in late January, 1958, was given up temporarily after a series of mechanical difficulties including accidental injury to personnel on the launching site. A third attempt, in early February, again ended in failure; the vehicle deviated from its planned course almost immediately after take-off, and the range safety officer had no alternative but to destroy it in the air.

Explorer

On January 31, 1958, the United States Army successfully launched America's first satellite, called Explorer. Using a modified Jupiter-C rocket, a 30·8-lb. baby "moon" was placed in orbit on the first attempt. The elliptical orbit, 200 to 1,800 miles, was so well established that scientists predict it is possible for the satellite to remain in orbit between 2 and 10 years. It is circling the Earth in a 114·6 minute cycle.

The launching vehicle itself was a 69-ft. long missile consisting of four stages. The first stage contained a liquid-propellant rocket engine.[6] Stage II[7] consisted of eleven solid-propellant rockets clustered in a circle with three Stage III[7] solid propellant rockets mounted inside



Vanguard—preparations for launching

the Stage II cluster. The fourth stage carried the satellite with one solid-propellant rocket as the propulsion unit. The satellite and Stage IV[7] rocket were designed to remain as one unit and the unit was not designed to be recovered.

The length of the entire launching vehicle was 823·3 in. (68·8 ft). The first stage was 672·8 in. (56·1 ft.) long and 70 in. (5·8 ft.) in diameter. The remainder of the vehicle was 150·5 in. (12·5 ft.) in length, including the satellite.

The liquid-propellant rocket engine burning a new high-energy fuel compound and liquid oxygen provided power to lift the Jupiter-C into outer space. The powerful rocket engine, in the 75,000-lb. thrust class, was modified from an engine used in the Army's Redstone[8] medium range ballistic missile. The new fuel used is a hydrazene-based compound nicknamed Hydyne. Hydyne's properties nearly duplicate those of alcohol. However, specific impulse, thrust and missile range were increased by 12 per cent. over that of conventional fuel.

The first stage lifted the composite vehicle into the thin high atmosphere, burned out and fell back to Earth. The remaining stages coasted to the apex of the arc (maximum altitude) and were then accelerated to orbital speed or about 18,000 miles per hour. (Satellite speed varies about 12 per cent. during its full elliptical orbit, slowing down as it approaches apogee. This change in speed is caused by gravitation, which retards satellite speed as it moves away from the Earth and accelerates it as it moves toward the Earth.) The first-stage powered the satellite to the prescribed distance from the Earth and the other stages (high speed stages) increased the velocity to orbital speed but did not send it to a greater height. The high speed stages were spin-stabilized in order to maintain the proper flight attitude. The rotational spin, more than 700 r.p.m., was initiated on the ground before the vehicle was launched.

The satellite itself consists of the instrument-carrying forward section of the cylindrical shell-casing and the fourth-stage rocket motor which is attached to the instrument carrier. The satellite is about 80-in. long and 6 in. in diameter. The electronic payload weighs about 11 lb., exclusive of the casing. Instrumentation and telemetry in the satellite are designed to gather and transmit four types of information: external skin temperature, internal temperature, cosmic dust erosion and cosmic ray data. The main part of the instrumentation package is a cosmic radiation experiment originally designed by Dr. James Van Allen of the State University of Iowa. The major element of this experiment is a Geiger-Müller counter. Dr. Van Allen's scientific experiment in the satellite is concerned with the measurement of rate and intensity of cosmic rays as they occur above the atmosphere of the Earth.

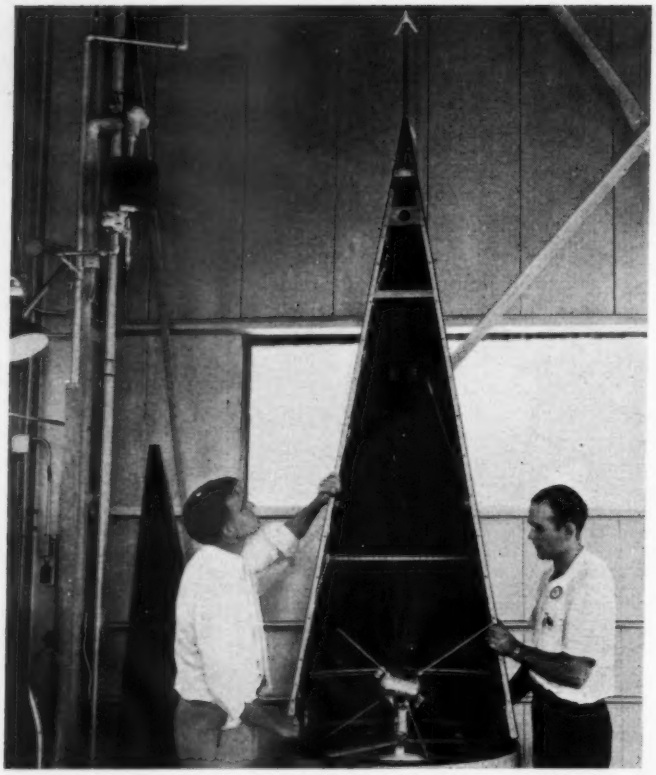
A second experiment—measurement of micrometeorite impact—is being performed by the Air Force Cambridge Research Centre, Geophysics Research Directorate, and was suggested by Dr. Maurice Dubin and Dr. E. Manring.

Engineers and technicians of the Navy's Vanguard Project are shown readying the 72-foot rocket vehicle for the test that with maximum success would have thrust the western world's first artificial satellite into space

Two miniaturized radio transmitters telemeter information to ground receiving stations located throughout the world. The low-power transmitter is sending information on skin temperature of the satellite forward area, nose cone temperature, micrometeorite impact data and cosmic ray counts. This information is sent on a frequency of 108·00 megacycles, using 10 milliwatts or 1/100 of a watt of power. Low power and long range are obtained using a band width of only a few cycles, This system, called Mircrolock, is expected to transmit information for several months. Amateur radio operators will probably be unable to recieve this signal. The transmitter weighs ½ lb. and the batteries 1½ lb.

The high-power transmitter is sending information on skin temperature on the rear section of the satellite, internal temperature, micrometeorite impact data and cosmic ray counts.

The miniaturized high-power transmitter is received on a frequency of 108·03 megacycles, transmitting with a power of 60 milliwatts or 6/100 of a watt. This transmitter utilizes the Minitrack stations and can be readily received by amateur radio operators. Its useful life is between two and three weeks. Both 108·00 megacycles and 108·03 megacycles are approved by the I.G.Y. and both systems have independent power supplies to insure reliability in the event of accident or malfunctioning of essential parts.



Inspecting half of a nose cone shell which will protect the 6·4-inch test satellite in its ascent through the upper atmosphere. The other half of the phenolic asbestos nose cone is standing against the wall in the rear of the Vanguard test tower. The two halves open up like a clam shell and are ejected early in flight well before the satellite is injected into its proposed orbit

Courtesy of Martin Company

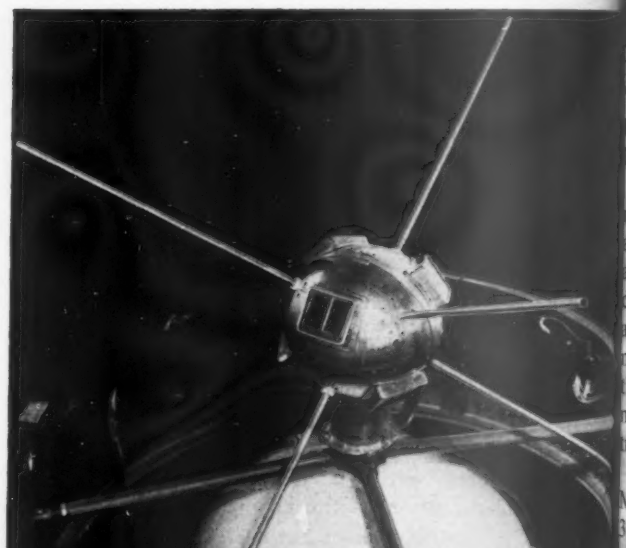
A nose cone temperature-sensing instrument telemeters information on nose tip aerodynamic heating over a the low-power Microlock transmitter.

In its orbit, the satellite radiates heat into space when it is on the dark side of the Earth and absorbs heat at a high rate when it is on the sun side of the Earth. As a result, skin temperatures fluctuate widely as it passes from the sun side to the dark side of the Earth. To control this wide temperature variation the instrumentation section and the nose cone were coated with strips of zirconium oxide at a ratio of 15 per cent. zirconium oxide to 85 per cent. bare metal. These eight $\frac{1}{4}$ in. strips are equally spaced on the forward section of the satellite. This striping, together with the fibreglass instrument carrier and the empty space between the instruments and the outer skin, hold the internal temperature range at a reasonable figure ($+6°$ C to $+45°$ C.)[9] and safeguard the sensitive electronic components. External skin temperature is ranging between $-0°$ C to $+72°$ C.[9] The other telemetered data include cosmic ray counts of heavy primary cosmic rays as they occur above the Earth's atmosphere, and information on the distribution, density, and relative momentum of micrometeorites in space.

In addition to collecting information on the rate and density of tiny little particulate bits of meteors in space, the satellite is equipped to detect the abrasive effect of dust-like clouds of micrometeorite particles which have a sand-blast effect. To perform this dual task, the satellite is equipped with two sets of instrumentation. An erosion gauge is located near the aft end of the final-stage motor. It contains a wire grid made up of 12 wires arranged in parallel. If the satellite runs into a sand-blasting cloud of micrometeorite matter, the wire grids will undergo erosion from the abrasive effects so that the wires may be cut. As each wire grid is severed there is a small change in frequency of the modulation on the low-power transmitter, indicating a micrometeorite five microns or larger. (A micron is a 40 millionth of an inch.)

In addition to the wire grid, the satellite is equipped with an impact microphone with an amplifier and scaler. The impact microphone is in spring contact with the outer shell of the satellite. When a particle of sufficient size and momentum impacts against the shell the amplified pulse actuates the scaler.

Output of this scaler controls the frequency of one telemeter channel of the high-power transmitter, so that when the frequency changes from low to high in the



The 6·4-inch baby satellite weighing $3\frac{1}{2}$ pounds. The power to transmit "beeps" back to the earth will be furnished by solar-powered batteries, which harness the sun's rays through small portholes on the satellites shell. The flexible cross-bars between the satellite and the rocket give support to the third-stage engine before it is spun-up and ejected from the burned-out second-stage. These cross-bars are also ejected soon after the third-stage leaves the protective cylindrical sleeve . . . some 300 miles above the earth

Courtesy of Martin Company

The gantry is being removed in preparation for the final launching with the rocket completely loaded and all systems checked

band, it will mean that the satellite has encountered a large particle.

When the frequency changes from high to low, it will mean that the satellite has encountered either a large or a small particle. Analysis of relative times in the high and low states gives an indication of the relative size distribution of the micrometeorites. An estimate of the absolute size and momentum of the particles will be made by calibrations selected prior to the launching of the satellite. The continuous cosmic ray count will be measured and telemetered simultaneously by both transmitters.

Total count of the cosmic rays hitting the Geiger-Müller tube in the satellite has been scaled down by 32 so that each unit of the 32 cosmic ray count will cause a step change in frequency in the instrumentation.

The average counting rate expected will produce approximately 32 pulses per second, which will cause a frequency change once each second. On this basis, the system is capable of transmitting cosmic ray information at 40 times the normal rate if such activity occurs during intense solar or magnetic storms.

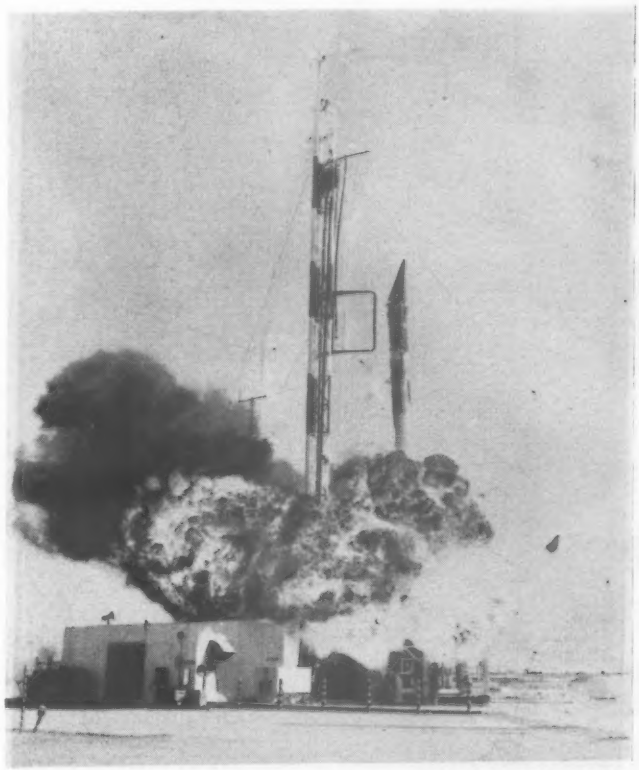
In addition to the information received directly from the satellite through its instruments, the vehicle also can provide basic scientific information simply by being in orbit.

Ground observations of the orbiting satellite will provide information about the ionosphere, geomagnetic field intensity and atmospheric density—information that up to now has been arrived at by calculations based on indirect evidence. Accurate optical and radio observation of changes in the satellite orbit may provide information as to gravitational anomalies in the Earth. It is known, for example, that the Earth is not uniform, and the suspicion exists that perhaps continents have more gravitational effect than do the oceans.

Additionally, world-wide maps may be changed from observations made of the satellite. Geologists have long desired some precise method of accurately measuring distances between continents. It has not been possible, of course, to stretch a tape measure between great land masses, so distances now are computed by triangulation and other methods that are not quite accurate down to distances of perhaps half a mile. It is felt by geologists that continents drift a few feet a year, but up to now there has been no way of determining if this suspicion is true. Observations made of the satellite, however, from two stations simultaneously can lead to precise calculations of distances between continents.

Artificial Meteors

Some very interesting U.S. experiments have received little publicity due to the over-shadowing satellite programme. These experiments have been extremely successful and point the way to a major scientific breakthrough in the future. In October, 1957, the U.S. Air Force blasted several "artificial meteors" free of the earth's gravity at speeds in the neighbourhood of 40,000 miles per hour. These "artificial meteors" were fired



After ignition, Project Vanguard Launching Vehicle falls back on launching stand and begins to burn

by means of shaped-charges placed in the nose of an Aerobee[10] rocket which was sent to a height of 54 miles over the New Mexico desert. The explosive is shaped in a manner which concentrates the blast in a forward direction and greatly increases its propelling effect. The aluminum BB-shot sized "artificial meteors" in the Aerobee rocket were lifted to approximately 33 miles altitude where separation of the nose cone occurred. The nose cone section than coasted to 54 miles altitude where the charges were detonated. The 54 miles altitude was chosen since this is the height at which natural meteors glow and can be seen. The explosion was very bright and approached a visual magnitude of −10. Photographs taken with a Baker Super-Schmidt meteor camera showed artificial meteor brightness of −4 visual magnitude or about the brightness of Venus.

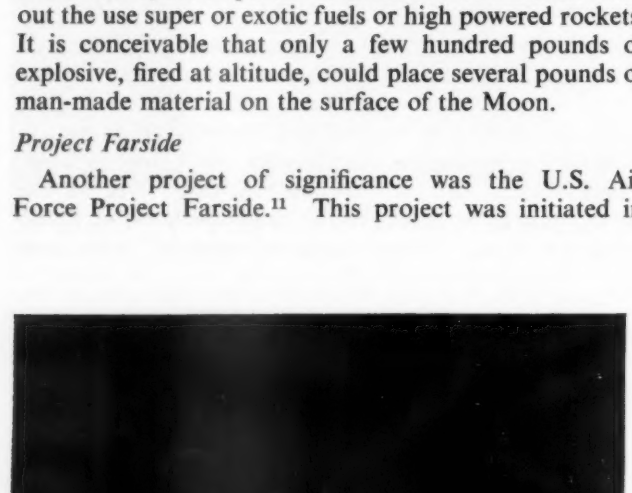
This programme is a very valuable tool for experiments in upper atmosphere physics and in addition is a possible method of hitting the Moon. Tremendous velocities, by this method, are imparted to small bits of material without the use super or exotic fuels or high powered rockets. It is conceivable that only a few hundred pounds of explosive, fired at altitude, could place several pounds of man-made material on the surface of the Moon.

Project Farside

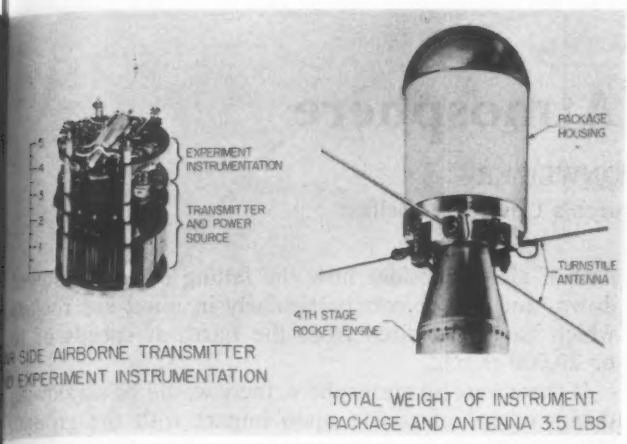
Another project of significance was the U.S. Air Force Project Farside.[11] This project was initiated in November, 1956, to investigate the feasibility of developing a vehicle capable of transporting an instrumented package to an altitude of several thousand miles. The vehicle configuration selected was a four-stage solid propellant rocket having an overall length of 30 ft. The first stage consisted of four Recruit[12] rockets, the second stage one Recruit rocket, the third stage four Arrow II[13] rockets and the fourth stage one Arrow II rocket. The instrumented package was attached to the fourth stage.

The purpose of the vehicle was to investigate phenomena at extremely high altitudes. This was accomplished by carrying to the desired altitude, a small but highly complex package of scientific instrumentation and an associated means of transmitting this collected data to ground receiving and recording stations. The information to be collected and transmitted to the ground was the measurement of cosmic rays, the Earth's magnetic field and the related effect of geomagnetic

Operation "FARSIDE" rocket assembly. The balloon is shown the bottom of the picture and it can be noted that the entire ro assembly was fired directly through the balloon. The first-s cluster of four rockets boosted the remainder of the vehicle to its 4000 mile goal



After the launching, billows of smoke shroud the burning Project Vanguard rocket



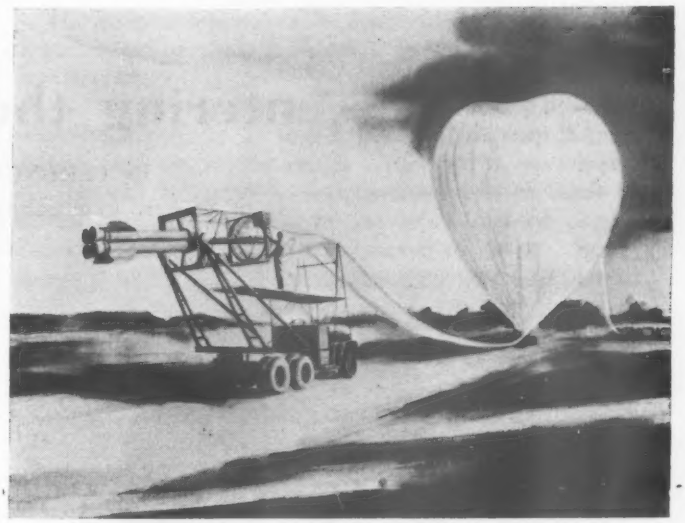
strumentation head or payload of operation "FARSIDE". hese instruments detected soundings in outer space and transmitted em to observers on the ground

storms on these measurements. The size of the instrumented package (approximately 4 in. in diameter and 6 in. in length) weight (3½ lb.), and the environment in which this package functioned demanded the development of a miniaturized radio transmitter capable of sufficient power to transmit the data under extremely difficult flight conditions from extreme distances heretofore never reached.

The launching platform was a 200 ft. diameter balloon which when fully inflated with helium had a volume of 3,750,000 cu. ft. and weighed 1,500 lb. The balloon ascended to between 70,000 and 100,000 ft. over Eniwetok Atoll in the South Pacific and the vehicle was fired through the balloon. Balloon assist was important because of the fast acceleration of the four stages. The vehicle's four stages were burned out in approximately eight seconds. The 25,000 ft./sec. terminal velocity was reached so quickly that launching from the ground would have ended in failure due to high aerodynamic heating and resultant damage to the nose cone.

The rocket attained a height of 4,000 miles although the exact altitude could not be determined due to radio transmitter failure. Data collected were expected to measure the Earth's magnetic field and obtain cosmic ray data. Preliminary analysis of telemetered data indicated that gravity, rather than decreasing simply as the square of the distance from the centre of the Earth, actually wobbles—i.e., both decreases and increases with distance. It seems that the Earth's strong electrical field and extremely dense "atmosphere" of charged particles up to 40,000 miles may be a factor.

Cloaked in a veil of security are a great many projects related to advancing the state of the art. Investigations of materials, instrumentation and guidance systems, fuels and many more are not as spectacular as a satellite or an "artificial meteor" being shot into space but are additive to overall basic knowledge. However, we can look forward to spectacular achievements resulting from this work now being accomplished.



The 3,750,000 cubic foot plastic balloon and the four-stage rocket assembly that was launched from an altitude of 100,000 feet in the successful attempt to penetrate "several thousand miles" into outer space

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" Nothing must go wrong this time, major, nothing! Before we connect up make sure the firing button can be pressed with the fingers crossed."

" Let's play Sputnike across his telescope."

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Entering the Atmosphere

By TERENCE NONWEILER
Dept. of Aero Engineering, Queen's University, Belfast

TERENCE NONWEILER

It is easier to fall than rise, says an old proverb: easier perhaps, but more damaging. Certainly, to judge by recent comment on Earth satellites and high-altitude rockets, getting them to rise is an accomplishment relatively easy compared with recovering them *intact* from their long fall back to earth. This may not be a true impression: getting rockets to go up involves principles which are known to everyone. Ensuring their safety in a fall is, on the other hand, a new problem which is probably not really so difficult after all, but which is solved secretly because the things to fall may be meant to drop on your neighbour's head.

Matters conducted secretly acquire an aura of mystery but there are a number of facts about this one which can be deduced by the uninitiated. The fiery fate of meteors in the night sky provides a clue to one particular problem—that of frictional heating. But it is better first of all to consider how the falling object is slowed down, and the objects particularly in mind are rockets which have been fired from the Earth at speeds of 10 or 20,000 m.p.h.

If there were no atmosphere, there would be no slowing down, except of course upon impact with the ground. To avoid such a catastrophe, the launching process would have to be reversed by forward-firing rockets; plainly coming down would then be just as difficult as going up, if not more so, as an error on the way up is not fatal like one on the way down. This is not so hypothetical a problem as it might appear as it is the one which necessarily confronts the would-be emigrant to an airless body like the Moon. It is also the reason why re-entry to the atmosphere has been thought so difficult, on the grounds that we dare not rely on the atmosphere itself to perform the slowing down. This attitude we shall see is unduly pessimistic: certainly the use of rockets for descent would be so complicated and expensive that it is not a severe competitor to this obvious alternative.

The resistance of the air will certainly slow down any high-speed intruder from outside, unless it happens to be a large and quite solid object, like a 10 ft. meteorite. Now water, by ordinary standards, seems a soft enough fluid, unless one meets it flat-on from a high diving-board; the air has the same effect upon anything which dives in from outside: it makes a very solid impression. To measure this, the most convenient unit is that of the acceleration due to gravity, abbreviated as g. So far as it affects the internal strains on the human body, 1 g is what we are used to every day: a sustained 5 g acceleration causes an aircraft pilot to black-out, though he can tolerate 10 g lying flat on his back. Further up the scale 40 g is the kind of momentary kick received by the pilot from an ejection seat, whilst 200 g is the impression soft ground makes when you fall from a first-floor window. It is also the impression that the atmosphere makes on an object entering it vertically downwards at 20,000 m.p.h. To reach this speed it would have had to fall from a height 7,000 miles. But even a headlong plunge from 1,000 miles is slowed down (from its entry speed of 11,000 m.p.h.) by a retardation of some 60 g, lasting for 2 or 3 seconds.

The curious fact is that this violent arrest is quite inescapable, depending only on the speed but not the size or shape of the falling body. A compact body just penetrates deeper into the atmosphere before it is slowed down, whilst one, say, with a parachute is affected in the same way in the more rarefied air higher up. The effect is primarily due to the rapid increase in air density

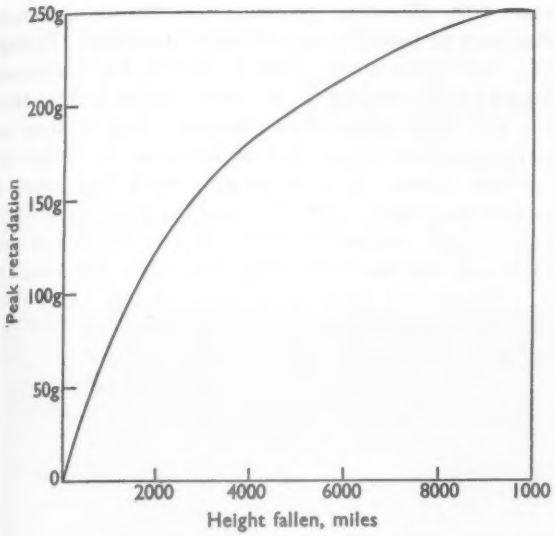


FIG. 1. The greatest deceleration suffered by a body falling vertically to the earth's surface

towards the Earth; close to the surface it doubles its value in every 3 miles of height.

The retardation is less severe if the angle of descent is not vertical, but more nearly horizontal. Such a descent will ultimately follow if the object merely skims the atmosphere at its first contact, in the way that an Earth satellite does. It curves close to the Earth during just part of each circuit it makes: here there is sufficient air to provide some slight brake on its speed which, acting time and time again in each circuit, finally causes the satellite to fall to Earth.

How soon this happens depends on the height at which it was finally launched into the orbit, for this is also the height of its closest approach the next time round. But the outcome is always that at length the satellite circles the Earth a little below this launching height, travelling at 18,000 m.p.h. As an example, the rocket of the first Russian satellite finished burning at a height of 125 miles with sufficient speed to carry it up to 600 miles above the opposite side of the Earth. After 2 months, the insidious action of the air brought it into a circle some 90 miles from the surface, and its final fall was imminent. (If it had been launched only 10 miles higher it would have taken twice as long for this to happen.)

In its final circuit it dived into the lower atmosphere at a shallow angle (of about 5°), and met a much softer form of air "cushion" than that experienced by a vertically falling object. The retardation was merely around 10 *g* for some 10 or 15 seconds. *Merely* 10 *g!* Enough to crush the senses out of any living thing, surely? Again this is quite inevitable, and the shape of the object only determines *when* it happens, and not *if* it happens. It could conceivably be alleviated by deliberately altering the shape of the falling body, so that it becomes more dart-like, and provides less resistance when the slowing down gets too rapid for comfort. This could prolong the agony and relieve the greatest strain, but it may not be an engineering proposition.

The initial skimming of the Earth's atmosphere is then a gentle and protracted process. It is the way by which interplanetary travellers are expected to slow their craft down to the circling speed of 18,000 m.p.h. when centrifugal force is no longer sufficient to keep it from falling back on to the Earth. This fall is, as we see, less gentle. Supposedly, instruments could be made to stand up to it, and maybe the late lamented doggy-occupant of Sputnik II was expected to do so. But it seems clear that manned satellites or space-ships will have to be built with wings, so that the dive into Earth can be made more gradual, with the help of the lifting force they provide.

The return to Earth will then be a series of circuits, progressively more circular in path, and then a long glide, in which the still enormous speed is gradually dissipated over a period of minutes (or if need be, hours) instead of within a few hectic seconds. If one accepts the fact that Earth satellites are only brought about by the research into the dreadful possibilities of the inter-continental missiles, one must also accept that the development of such a glider depends on whether H-bombs can withstand high retardation. Certainly, the Germans were planning at the end of the war this kind of landfall for their I.C.B.M.

But let us not forget the fate of the burning meteors. The large majority of these, we are told, are minute solid particles careering headlong at the Earth at 60,000 m.p.h. or so. Evidently their retardation must be extraordinarily severe. Their burning is caused by air friction, and is a vivid illustration of the same principle that, after all, accounts for burning break-drums, sparkling grindstones and other sundry domestic phenomena—a vivid example, but a more complicated one. Friction is one form which air resistance can take: there are others. As air resistance is essential for slowing down, keeping cool at the same time implies that as little of this resistance as possible derives from friction. This means making the vehicle bluff in shape: for example, spherical rather than dart-like. Also, since the heat supplied from the air depends on how much air there is, it helps if the retardation takes place high up, where the air is thinnest. This means making the vehicle light in weight for its size. The meteor's fate is therefore not a fair guide to the problem, as it is small and solid. Moreover,

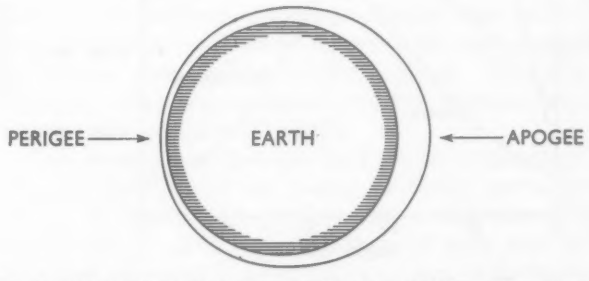


FIG. 2. The initial orbit of Sputnik II (to scale). The point of closest approach (perigee) is taken in the text as also the launching height because it is probable that when the rocket finishes burning the direction of motion is horizontal. At the other side of its elliptic orbit the satellite is at its furthest point away (apogee)

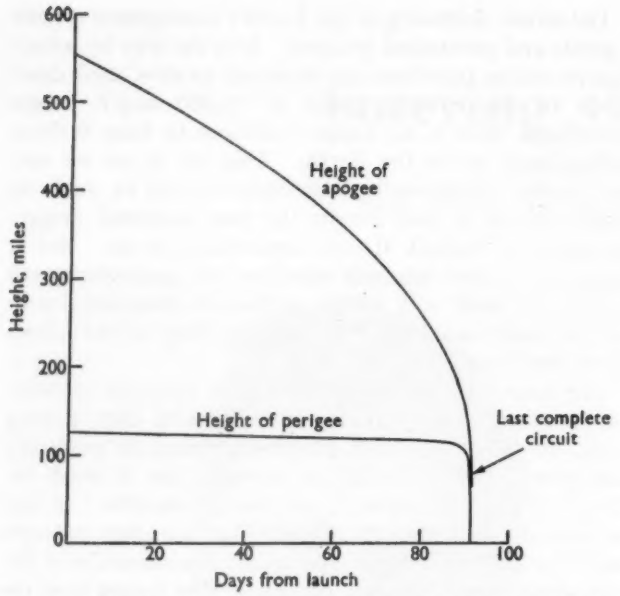


FIG. 3. The closest and furthest heights of the Sputnik I during its three months of existence (calculated data). The time scale of its actual orbit was more compressed due to unexpectedly higher air density

its high speed increases the amount of heating tenfold or more.

These considerations apply equally to the design of a winged glider re-entering the Earth's atmosphere if it is not to melt away. Its wings may be blunt-nosed, and it must fly high: this means giving it a great expanse of wings for the load it has to carry, and making full use of them by flying in the high-angled, nose-up attitude most aircraft only adopt when landing. In fact, it would be the very opposite of the current notion of a fast aircraft; but then it would be meant to lose speed, not gain it.

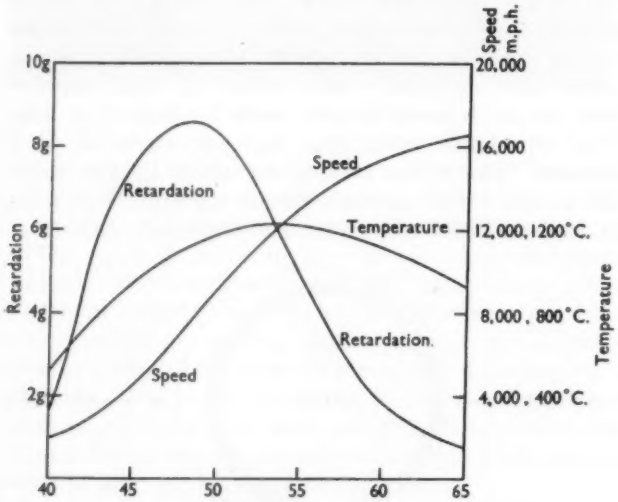


FIG. 4. The critical period in the descent of a satellite vehicle. The quoted height at which this sequence of events takes place is typical of something like the Sputnik I. The temperatures quoted are purely tentative, but show that the vehicle gets hot before it slows down

Even with all these precautions, the temperatures reached may be large by any ordinary standards. Perhaps 500° C., and more than 1,000° C. at the hot spots near the nose,—red-hot spots in fact. Admittedly, these figures are little more than guesses. But if they are right, the problem would not be intractable. After all, the turbine blades of a jet engine work for hours at temperatures around 1,000° C., and the vital parts of the satellite's cargo, human or otherwise, can be refrigerated. Many would feel this is an optimistic view: they could be right. Those who know best dare not tell. Certainly, the problems may be easier to solve for a glider than a free-falling object, as the latter heats up before its speed has fallen very much. It is the subsequent intense retardation acting on a structure softened by heating that is likely to cause it to disintegrate in mid-air.

Subscriber's Lament

I joined the British Interplanetary Society to go to the Moon—
Reasonably soon.
I wanted to hear about landings on Venus and Mars
And thrilling Einsteinian flights to the stars.
But, whenever I open the infernal
B.I.S. Journal,
Instead of pictures of exciting, space-suited people
Setting off in some great, gleaming ship as tall as a steeple,
All I find is a welter of maths
Describing their paths.

Confound all these Cleavers and Cleators—these dabblers
In propellants, parameters: pumps and parabolas—
Who flaunt their calculus, all spiky and bristly,
While the tone of their efflux grows more guided-missily!
I think it's indecent, filling the Society's publications
With all this rough-work and calculations.
How would they like it if physiologists detailed, in every issue
All the writhings and twitchings of lab-tortured tissue?
(Anyway, I thought it'd all been worked out years ago by
Oberth and Esnault-Pelterie
That terrible stuff, all Sigma—and Theta—and Delterie.)

Let's hear more about spaceships and stations—
I'm sick of these endless specifications
Of Nikes and Matadors, Snarlers and Mice
(Which just hop about poor Earth's surface, like lice.)
They'll no more carry me to distant planets
Than a sixteenth-century gondola, drawn by gannets.
So come on, you theoreticians, let us reach for the sky
(With a little help from the Ministry of Supply!)
Build me a vehicle, find me a crew—
All I ask is a space-ship and a star to steer her to!

J. G.

The London Planetarium

By H. C. KING, PH.D., M.SC., F.R.A.S.

The London Planetarium is the first to be opened in the British Commonwealth. In this article Dr. King, Chief Narrator, gives us an account of it.

DR. H. C. KING

Dr. H. C. King is a science graduate of London University. He has been a member of the B.A.A. for 24 years, and from 1949 was senior lecturer in Ophthalmic Optics at the Northampton College of Advanced Technology. At the beginning of 1958 he took up his new position as chief narrator at the London Planetarium

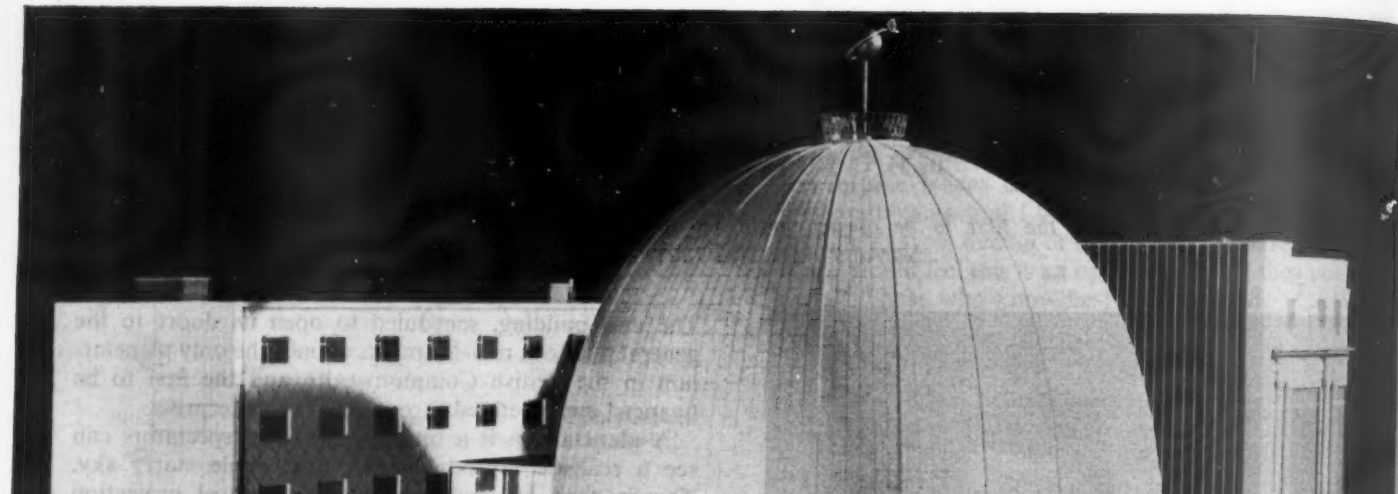
From time to time since 1925 there has been talk in educational and scientific circles about the desirability of having a planetarium in London. Yet whenever the project looked like receiving official sanction, financial and other difficulties caused it to be shelved. In 1927, for instance, the General Purposes Committee of the London County Council stated that it could not recommend the Council to build a planetarium "as astronomy is not extensively studied". But although shelved, the project was certainly not forgotten, the more so because of the rapid rise of public interest in astronomy and spaceflight in recent years. Hence it came about that about two years ago the foundations of The London Planetarium were laid on a site in Marylebone Road. The new building, scheduled to open its doors to the general public in mid-March, is at once the only planetarium in the British Commonwealth and the first to be financed and operated through private enterprise.

A planetarium is a building in which spectators can see a realistic reproduction of the whole starry sky. This is done by placing a complex optical projection instrument at the centre of a large hemispherical dome. Images of the Sun, Moon, planets, and stars are then projected on to the white-painted inner surface of the dome. By rotating the projectors, singly or in groups, the images formed on the dome trace out their individual paths in the planetarium sky. Spectators seated inside the dome thereby witness the diurnal motion of the stars, the relative movements of the Sun, Moon and five naked-eye planets (Mercury, Venus, Mars, Jupiter, and Saturn), and even the long-term effects of the precession of the equinoxes.

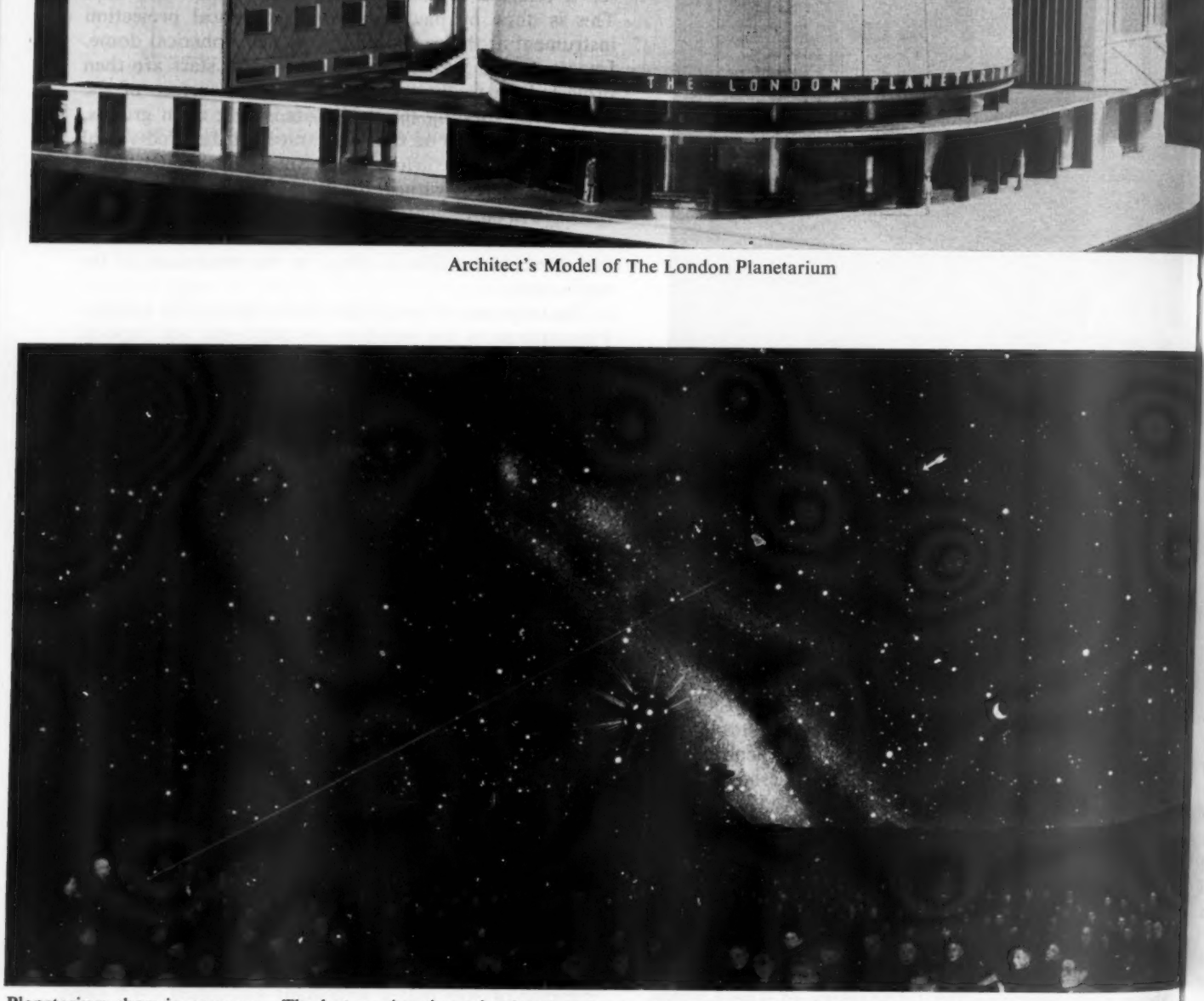
The large central projection instrument in The London Planetarium is the product of engineers and optical technicians at the Zeiss works in Western Germany. It takes the form of a 12-ft. long dumb-bell supported by a rigid frame built of thin steel bars. The two "balls" of the dumb-bell are hollow 30-in. diameter globes from which the stars are projected. The connecting "bar" contains the projectors for the Sun, Moon and five planets.

Between them the two star globes provide some 8,900 stars for both hemispheres, that is, they provide all the stars from the brightest to those of magnitude 6·5. These stars are correctly graded according to brightness and accurately positioned relative to each other for the epoch 1900·0. The images originate from star plates prepared in a most ingenious way. Large sheets of matt-black metal are used as a base. On these are pasted disks of white paper of the appropriate sizes and in the correct relative positions to represent the naked-eye stars in selected areas of the celestial sphere. The finished plates are then photographed and the negatives used to prepare photo-engraved plates.

The planetarium stars are neat, circular images of the tiny apertures of the star plates, or better, star diapositives. Illumination is provided by a 1000-watt bulb of special design placed at the centre of each star globe. The light from this is collected by sixteen radially-placed aspherical condenser lenses and passed through the same number of star plates with their associated f/4·5 Zeiss *Tessar* lenses. In this way a mosaic of sixteen separate



Architect's Model of The London Planetarium

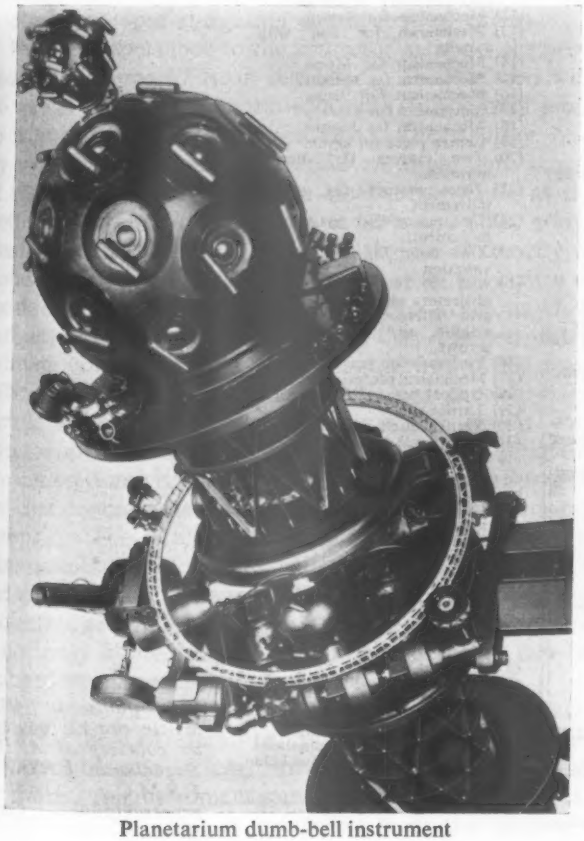


Planetarium show in progress. The lecturer is using a luminous arrow to point out the constellation Corona Borealis. Autumn aspect of the morning sky

but completely integrated star fields can be projected on the dome.

With earlier-type Zeiss planetarium instruments this mode of star reproduction had one disadvantage—the brightest stars were represented by large disks. Their obviously large size (about 2 in. for a dome 65 ft. in diameter) and frequent foreshortening (for spectators seated near the dome surface) detracted from the otherwise realistic effect. In the Zeiss projector for London, however, the images for the 42 brightest stars of both hemispheres are projected by the same number of special supplementary projectors mounted on a ruff at the base of each star globe.

By turning the dumb-bell about a horizontal east-to-west axis it is possible to show the appearance of the starry sky for any terrestrial latitude. A popular feature in planetarium demonstrations is to take spectators on an imaginary trip from pole to pole and so to introduce them to unfamiliar skies. At all times, of course, the star images are confined to the projection dome; otherwise they would run across the faces of spectators and spill themselves over the floor of the auditorium. This is achieved by fitting mechanical blinkers or artificial eyelids over the star projectors. As any one projector approaches the level of the planetarium skyline, a gravity-controlled blinker swings across the lens aperture and gradually reduces the brightness of the star images until they fade away completely.



Planetarium dumb-bell instrument

The diurnal motion of the stars is produced by rotating the dumb-bell about a vertical axis, the dumb-bell being itself fixed at an angle of $23\frac{1}{2}°$ relative to this axis. This important motion can be effected in 12 minutes at the longest or in 3 minutes at the shortest. The precessional cycle of 25,800 years is reproduced by a 4-minute rotation of the dumb-bell around its long axis. As far as the stars only are concerned, the dumb-bell can be set to show the appearance of the night sky for any place on the Earth's surface and for any time, past, present or future.

The complete extent of the Milky Way is catered for by two drum-type projectors. Its very nature suggested the means of reproducing it in the planetarium. Large drawings of its appearance were made by using stippling of the correct intensity and density. The drawings were then photographed and the films placed inside two drum-shaped projectors so as to form in the planetarium sky a faint diffuse band of innumerable stars.

An intricate system of gear-trains and mechanical linkages applied to the Sun, Moon and planet projectors ensures that their images keep to the precise paths and move with the correct proportionate motions across the planetarium sky. In accordance with the geocentric viewpoint, the planets are each seen to trace out their appropriate loops or pendulations, those of Mercury and Venus keeping close attendance on the Sun. The brightness of the planetarium sun is of course purposely reduced so that it can be followed on its annual course among the stars of the zodiac. Both the maculæ and the phases of the moon are shown, and to assist in distinguishing one planet from another, the planets appear with sensible disks. Saturn has rings, Jupiter appears with belts, and Mars has a ruddy hue.

From time to time in planetarium demonstrations it is necessary to run the entire instrument back in time. To reproduce the relative dispositions of the planets in the night sky of March 20, 1858, for example, the Sun, Moon and planet projectors have to be run back 100 planetarium years at the maximum rate of 10 seconds a year—an operation taking nearly 17 minutes. The precessional motion, on the other hand, can be operated on its own. The starry skies of A.D. 14,000, when the bright star Vega will be the "Pole Star", can therefore be shown in a matter of minutes. In general, the motions which in nature are of short period carry with them those of longer period; hence an appropriate precessional change automatically accompanies the annual motion.

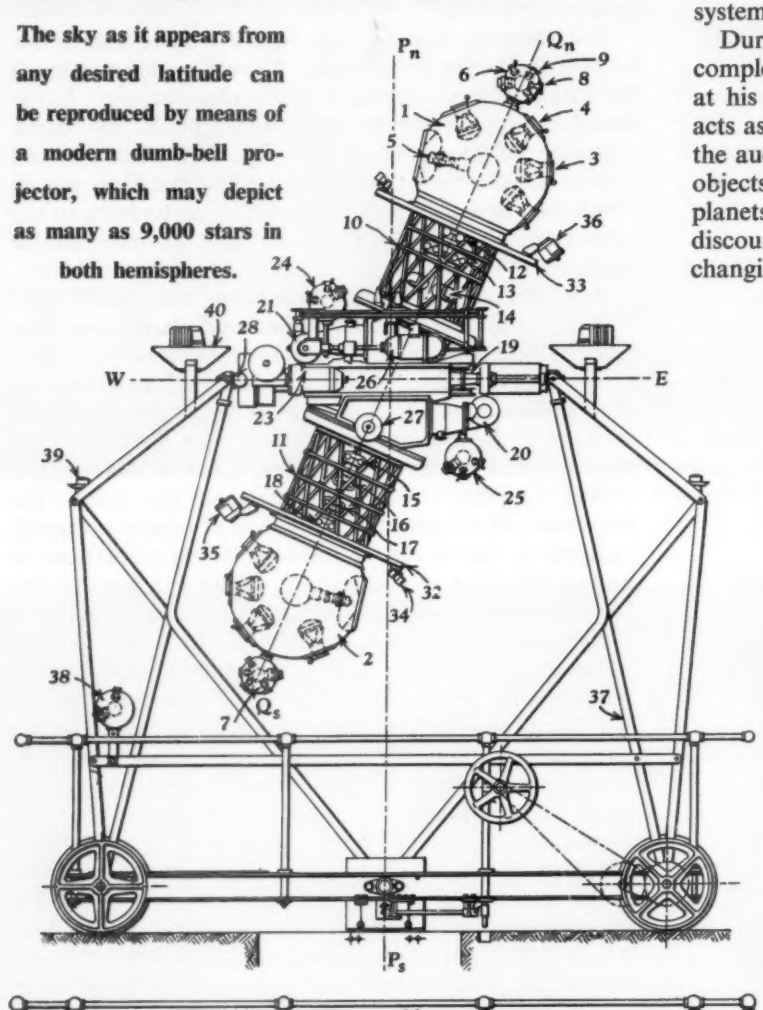
Also mounted on the main instrument are projectors for showing a great variety of interesting objects and appearances. Among them are the three variable stars: Algol, Delta Cephei and Mira Ceti (complete with light variations); comet Donati at its 1858 apparition; the counterglow or gegenschein; the zodiacal light and solar aureole; constellation names (in both Latin and English); the parallactic motion of Sirius; the meridian, ecliptic, mean sun, celestial equator, PZS nautical triangle and

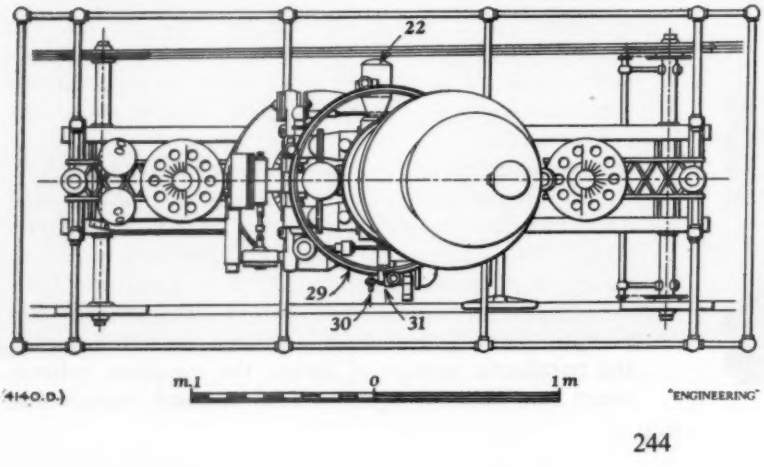
part of the Right Ascension—Declination co-ordinate system.

In addition to the main instrument, The London Planetarium contains a number of separate auxiliary projectors. One of these shows eclipses of the Sun and Moon, the total solar eclipses being accompanied by views of the corona and prominences. A shooting star projector reproduces either sporadic meteors or a great meteor shower; a small drum-type projector provides the constellation figures for both hemispheres. With yet another instrument it is possible to show the solar system as seen from a viewpoint well outside the orbit of Saturn. In this way spectators can watch the relative heliocentric motions of the planets, and by means of an additional "light line" which connects the circling Earth and any other circling planet, see how these motions lead to the geocentric apparent paths of the planets. By giving the whole instrument a conical movement so that the revolution of the Earth about the Sun is halted it is also possible to demonstrate the scheme of the solar system according to Tycho Brahe.

During the course of a lecture session the lecturer has complete control over each and every projector. Standing at his console near the northern face of the dome, he acts as a perfect guide for some 550 spectators seated in the auditorium. Whether he is pointing out interesting objects in the night sky, illustrating the ways of the planets, or describing the architecture of the heavens, his discourse must be completely integrated with the changing appearances which he alone initiates in the

The sky as it appears from any desired latitude can be reproduced by means of a modern dumb-bell projector, which may depict as many as 9,000 stars in both hemispheres.





(1 and 2) Two fixed star globes
(3) Projectors, 16 per globe
(4) Mechanical shutters, 16 per globe
(5) 1,000 watt lamp, one per globe
(6 and 7) Two globes for constellation names and precession dial
(8) Projectors, 15 per globe
(9) Mechanical shutters, 15 per globe
(10 and 11) Two planetary frameworks with double projectors and planetary mechanisms
(12) Mechanism for Saturn
(13) Mechanism for Sun with aureole
(14) Mechanism for Moon
(15) Mechanism for Mercury
(16) Mechanism for Venus
(17) Mechanism for Mars
(18) Mechanism for Jupiter
(19) Centre piece on cradle
(20) Two motors for diurnal movement
(21) Three motors for annual movement
(22) One motor for precessional movement
(23) One motor for polar altitude variation
(24 and 25) Two globes with 6 projectors each for equatorial grid reference system and ecliptic, and for two pole arrows
(26) Projector for year counter
(27) Mechanical precession counter
(28) Optical polar altitude reader
(29) Lattice ring
(30) Vertical circle projector
(31) Hour circle projector
(Above three items comprise equipment for demonstrating the mean sun and the nautical triangle)
(32 and 33) Two ruffs between fixed-star sphere and planetary framework
(34) 45 special projectors for the 42 brightest fixed stars and the three variable stars Algol, Mira Ceti, Delta Cephei
(35 and 36) Two Milky-Way projectors
(37) Carriage frame
(38) Two spheres with two projectors each for meridian
(39) Two horizon illuminations for morning and evening
(40) Two dome illuminations providing white and blue light

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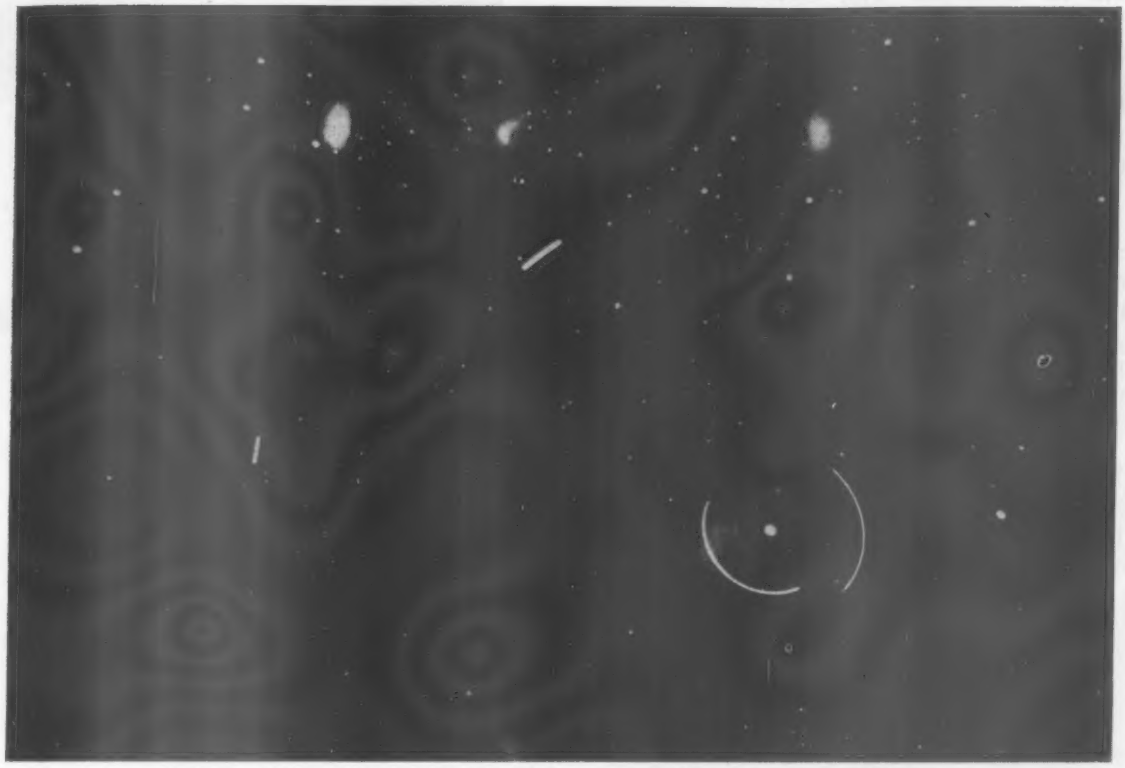


Trails of fine planets, earth included, formed by Zeiss solar system projector

planetarium sky. He also operates a slide projector and controls any special lighting and acoustical effects.

Next in importance to the projector arrays is the great projection dome 67 ft. in diameter. This is faced with 16 gauge aluminium sheets screwed, with a butt joint, to a sub-frame of aluminium ribs. The ribs are held by two tubular tension rings and an aluminium saucer at the crown, and bolted to a steel substructure at the bottom. Around the inside of its base, and 10 ft. above the floor of the auditorium, is the skyline of the city of London in sharp silhouette. Viewed from the centre of the floor the dome presents a completely continuous white surface, but close inspection reveals that it is perforated with millions of tiny holes. These holes, of diameter 0·08 in. and density 20 per sq. in., are necessary for ventilation and acoustical reasons; they in no way affect even the smallest star images. Surrounding the projection dome is the slightly conical structural dome of pre-cast concrete slabs faced on the outside with copper sheeting. The 5-ft. space between the two domes contains access corridors and galleries, also the necessary metal ducting of the ventilation system. Since optical projection requires very clear air, the air in the auditorium is not only filtered at the main intake duct but can be changed as many as eight times per hour.

Thirty-two Zeiss planetaria have been erected to date, but in all these the dumb-bell instrument is a permanent feature of the auditorium. In The London Planetarium the entire 2-ton instrument stands on the floor of a vertical lift mechanism. This is controlled from the lecturer's console and raises the instrument from its exhibition position in the entrance foyer to its operating position in the auditorium. When not in use, therefore, the instrument stands in a glazed drum in the centre of the foyer and can be inspected by visitors and seen by passers-by from the street outside.

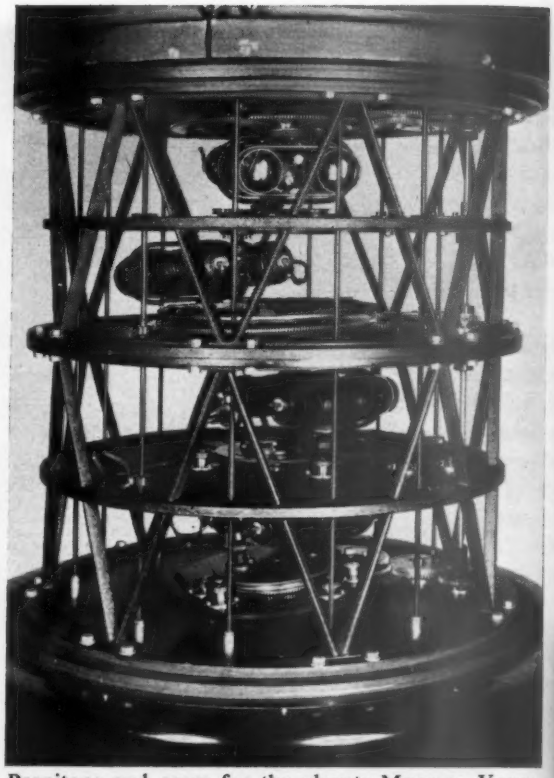
Like the dumb-bell instrument The London Planetarium building is a model of compactness—not 1 sq. ft. of space has been wasted. With several Zeiss planetaria on the Continent and in the United States of America there is associated an astronomical museum or even observatory. Space and location preclude attractive cultural extensions of this nature in London, and in any case, room had to be made for the necessary staff-offices, library, photographic dark-room, rest-rooms, etc. This additional room space has to be the larger since it is planned to make the planetarium the centre for the dissemination of astronomical information for the public of the British Isles. In the auditorium lecturers will be concerned with the presentation of the facts of astronomy in the simplest and most attractive way. The same approach will be adopted outside the auditorium, whether it be in the preparation of special foyer exhibits, articles, brochures and books, or in their personal contacts with the press and educational institutions. Future developments in spaceflight in particular and space research in general will also receive attention. Both can provide valuable and interesting lecture topics, though here again the planetarium will present facts rather than imagined possibilities. In brief, the

project will be conducted with complete scientific integrity.

The necessary research into the best ways of representing astronomical information on the widest possible basis will certainly involve trials with all manner of additional stage and technical effects. For as Dr. Werner, head of the astronomy department of the Zeiss works, points out, the planetarium can best be compared with a theatre. "In addition to communicating positive knowledge" he writes, "it must leave the spectator with a deep ethical impression of the wonders of the heavens." On this count alone, publicity and lecture displays must be dignified and accurate. The public, as the American astronomer B. J. Bok has remarked, will soon lose interest in presentations of scientific results if the fundamentals of scientific honesty are not strictly observed.

It can no longer be claimed that "astronomy is not extensively studied". Recent increases in the number and variety of published books, periodicals and articles devoted to or bearing on astronomy, the rapid growth of astronomical associations, societies and clubs, the widening public interest in scientific matters in general and in the activities associated with the I.G.Y. in particular—all these indicate that astronomy has a growing popular appeal, that it is, in fact, being extensively studied. This development, moreover, is occurring despite the restrictions of atmospheric pollution and artificial lighting which invariably accompany town and city developments. In this country we have no mountain observatories open to public inspection on one or two nights of the week, no building, museum or exhibition planned on a large scale to give the ordinary man some insight into the findings of modern astronomy. No optical firms urge the public to buy a telescope from an impressive range of telescopes. Even amateur astronomers, anxious to possess a good instrument, soon learn that they must make-shift for themselves.

Under the circumstances, therefore, the opening of The London Planetarium is singularly opportune. As a medium for illustrating the facts of astronomy it is unrivalled. Visitors enter its walls seeking entertainment; they leave enthralled by the wonder and majesty of it all. Once their interest is aroused they will be ready to look further, perhaps by following up some or all of the monthly topics at the planetarium, by reading about astronomy, or maybe by going out under the night sky and finding things out for themselves. The planetarium lectures and publications are planned to initiate these reactions. They make a direct appeal to folk who know next to nothing of even the most elementary aspects of astronomy.



Propitons and cages for the planets Mercury, Venus, Mars and Jupiter

Mechanical eyelid over star projector

Photographic Observations of Artificial Earth Satellites

By Dr. M. J. SMYTH
Dunsink Observatory

Observations Needed

Important information about air-drag, the shape of the Earth and related topics will be gained from study of the motions of artificial Earth satellites, and amateur astronomers can contribute useful data for this analysis. While the United States (and presumably the Soviet Union) are setting up several complicated and expensive tracking cameras capable of the extremely high accuracy of 2 seconds of arc and 0·001 second of time, data from these require to be supplemented by frequent less precise measurements made with simple equipment at numerous sites; these positions will be used both for immediate orbit predictions and in the final analysis. And since the U.S. tracking cameras will be sited in the low latitudes from which their first satellites will be visible, while the Russian cameras are restricted to Soviet territory, observers in the British Isles can make a useful additional contribution. Our position near the "apex" (65° N) of

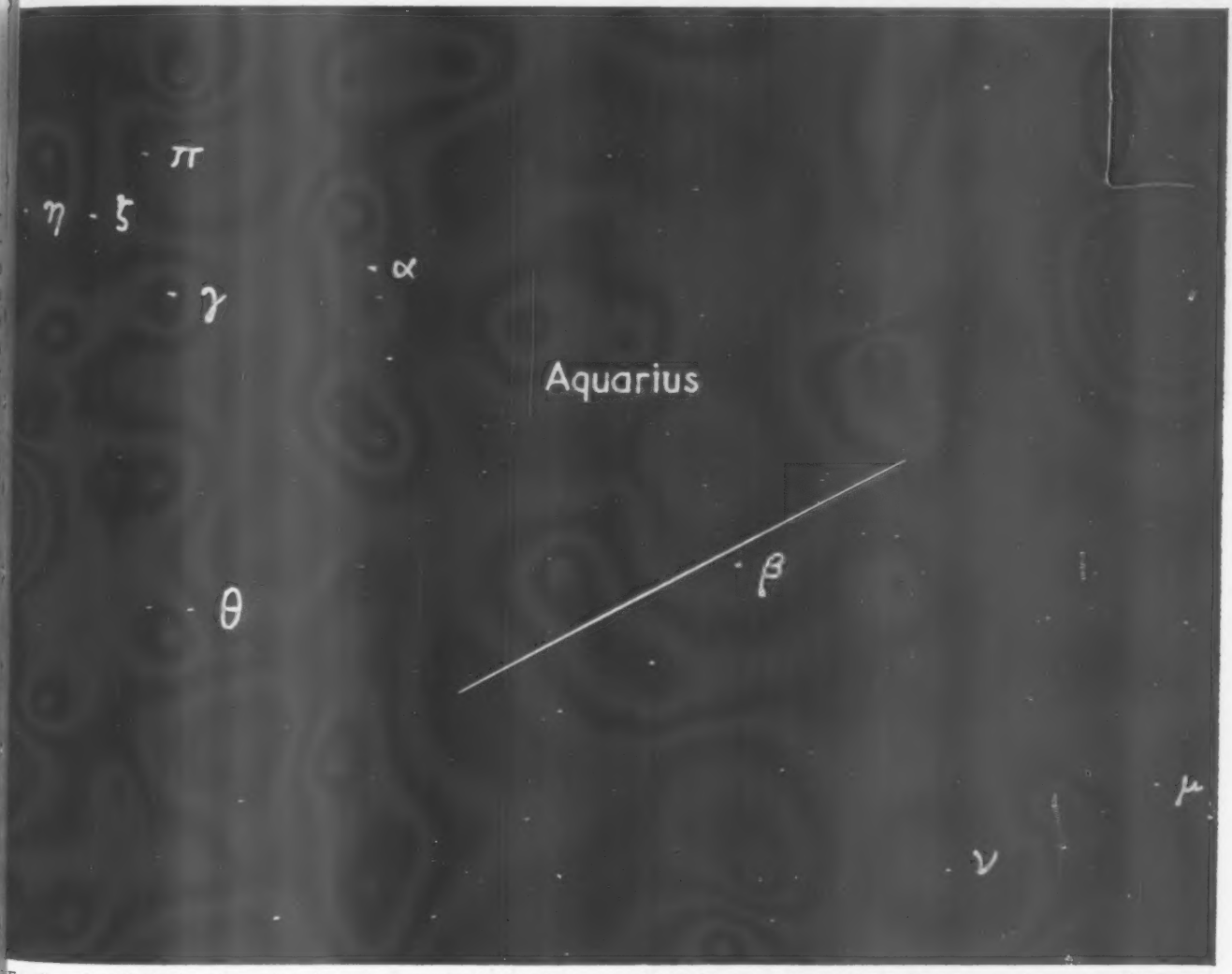


FIG. 1. Soviet Rocket 1 passing through Aquarius, 1957 November 23 $18^h09^m19^s - 18^h09^m39^s$. Stars down to 8th magnitude are clearly recorded. All photographs taken with Leica 35 mm. camera, 5 cm. f/2 Summicron, Kodak Tri-X film.

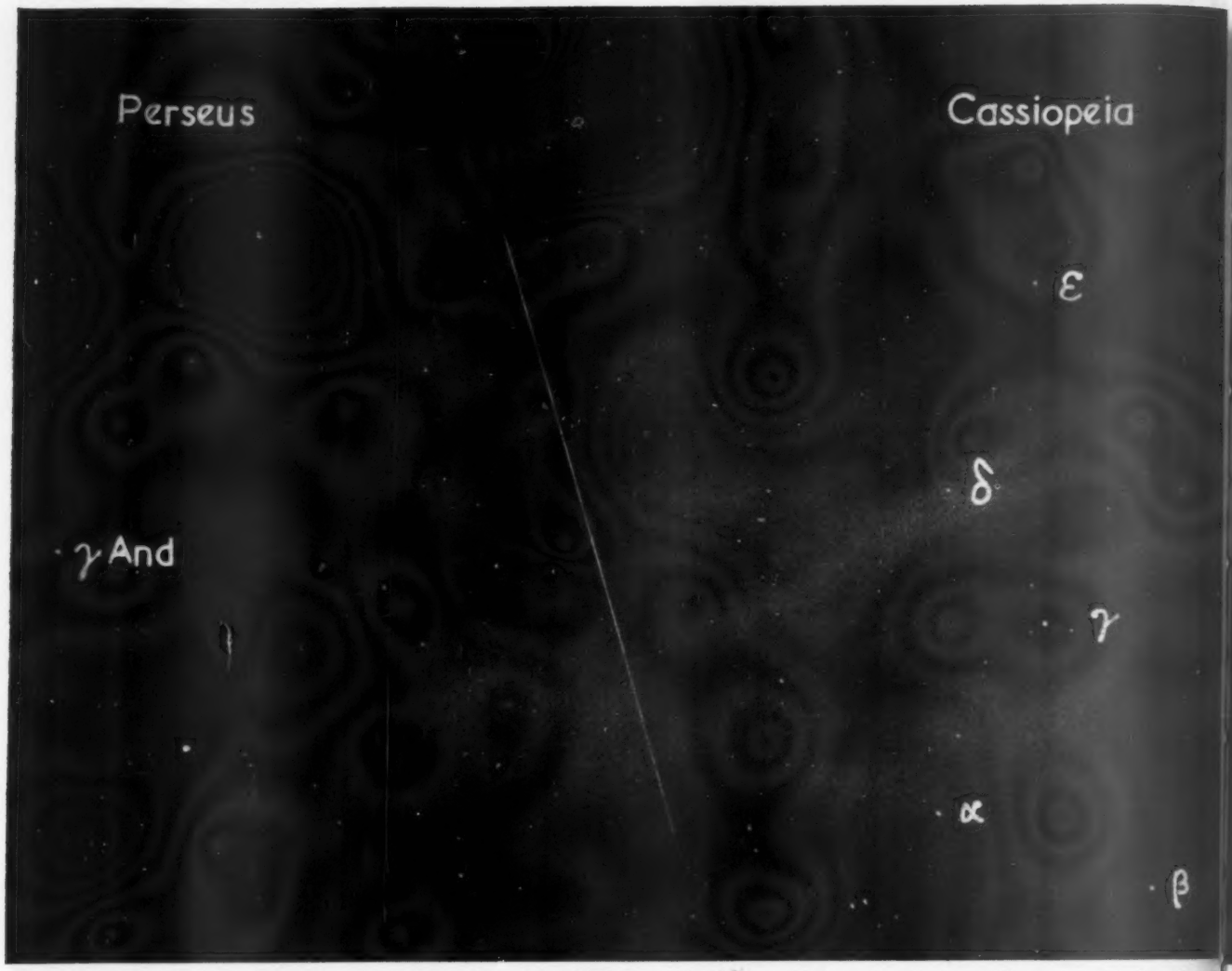


FIG. 2. Rocket 1 rising in Cassiopeia, 1957 October 14 $05^h20^m02^s - 05^h20^m24^s$. Stars and trail are readily measurable in spite of thin moonlit cloud.

the present orbits ensures frequent visibility, and our longitude is the most westerly available until America is reached.

The large "Moonwatch" teams organized in U.S.A. and U.S.S.R. for visual observations, to provide data for predictions, are unlikely to be formed here. Fortunately the Soviet satellites (Rocket 1 and Satellite 2) are larger and very much brighter than the proposed U.S. satellites, so that individual observers can measure positions with the naked eye, theodolites or small cameras. Of these methods, photography yields most information, is simple, and gives a permanent record, so that errors due to haste are unlikely.

Photographic Technique

The type of camera is unimportant, so long as sharp star images are obtainable all over the field. The photographs illustrating this article were taken with a Leica miniature camera with 5 cm. f/2 lens; equally successful photographs have been taken with cheap 35 mm. cameras, twin-lens roll-film reflexes, and ¼-plate press cameras. On film, successive exposures may be made as the satellite crosses the sky; this is less easy with plates, which are, however, more convenient to develop for single exposures. In recording faint stars, which are required to form a background for measuring the positions of the satellite, it is the linear aperture rather than the aperture ratio of the lens which determines the magnitude limit, 5 cm. f/2 being approximately equivalent in this respect to 10 cm. f/4, for example. The normal-focus camera lens, with a field of about 45°, is generally most useful. A wide-angle lens records an unnecessarily large expanse of sky on a small scale, and its linear aperture is small; while the small field of a long-focus lens increases the chance of missing part of the trail, and the small star-field is harder to identify.

The fastest available photographic emulsion will be used, in order to record faint stars and to deal with the slow brightness fluctuations of the satellite as it spins. As a guide, the photograph in Fig. 1 had 20 seconds at

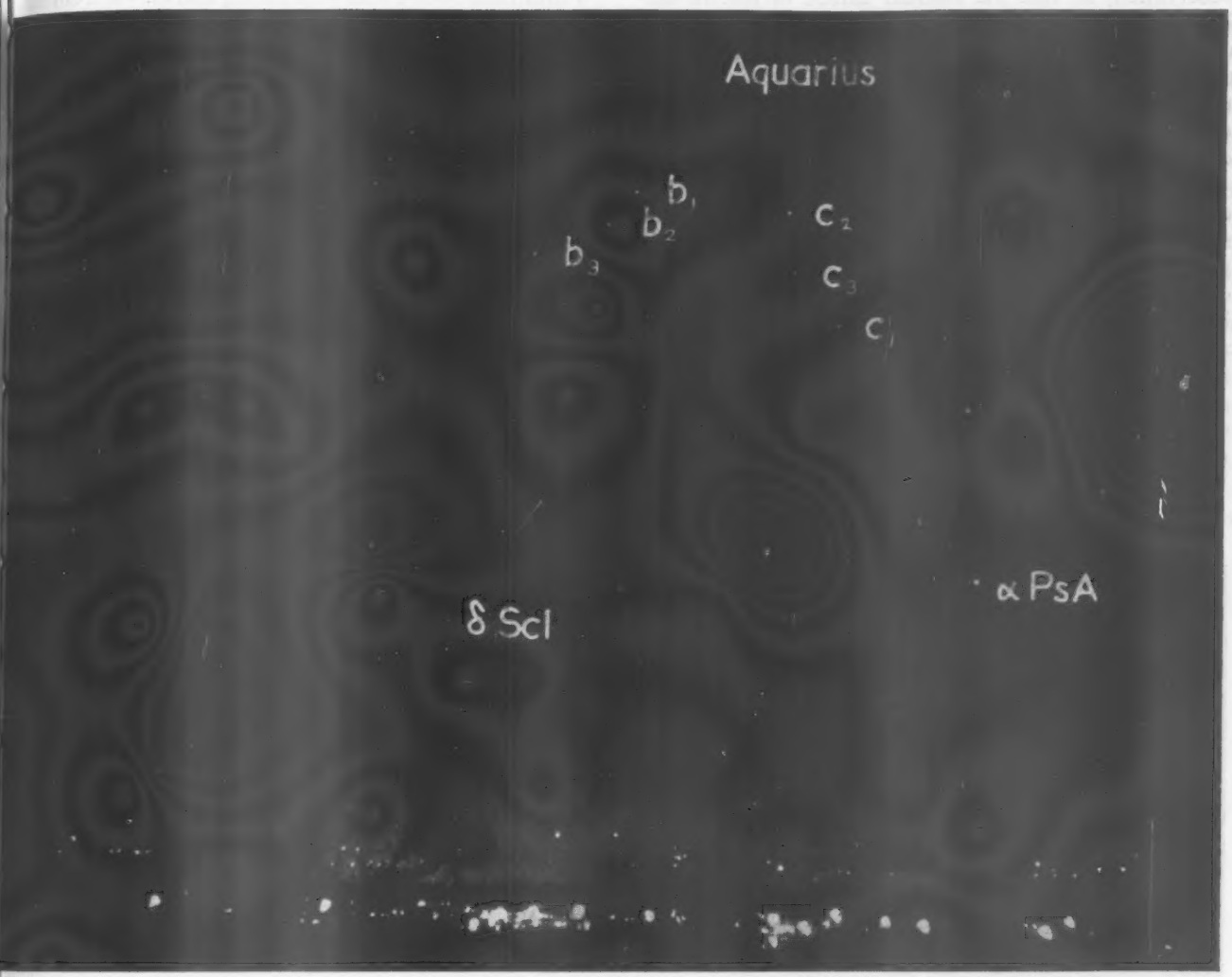


FIG. 3. Rocket 1 setting in Sculptor, 1957 November 23 $18^h11^m49^s - 18^h11^m59^s$. Photograph to same scale as Figs. 1 and 2, illustrating small apparent motion when distant and moving nearly in the line of sight.

f/2, 5 cm. lens, Kodak Tri-X 35 mm. film; stars down to 8th magnitude are clearly registered, which facilitates position measurements. Development times may advantageously be increased, up to twice normal, as graininess does not much affect the measurements. When the sky is hazy or lit by twilight (as to some extent it must be if the satellite is to be visible) or by moonlight, exposure times may need to be further curtailed in order to avoid heavy background fog which obscures the star images. Colour filters may also help to darken the sky. Useful photographs can be taken through *thin* cloud, as Fig. 2 shows, but the constellations are then more difficult to identify.

It is important to use a firm stand for the camera, as very slight vibration distorts the trail and enlarges the star images. The heavier centre-pillar tripods or the older types of wooden stand are better than lightweight collapsible tripods. A ciné pan-and-tilt head is preferable to a ball-and-socket, because the observer has to follow the satellite and then lock the camera firmly and wait for vibration to subside before exposing. If the shutter release ("B" or "T") tends to jar the camera, it is better to open the shutter in advance and to begin and end the actual exposure with a card held in front of the lens.

Timing

Amateurs may find accurate timing of photographs difficult, but this is just as important as accurate position measurements. Roughly speaking, the satellites move through 1° in 1 second, and positional accuracy of 0°·1, which is easily achieved, really needs to be matched by timing accuracy of 0·1 second. An accuracy of 1 second will, however, be acceptable for some purposes, but it must be emphasized that if the uncertainty of timing exceeds 1 second the photograph will be practically useless to computers, and may cause errors.

A good watch with clearly readable seconds' hand can be used if its error is checked by the B.B.C. "pips" or other accurate radio time-signals before *and* after the

observation, so that the amount gained or lost in the interval can be allowed for. A seconds' pendulum clock, such as some amateur astronomers possess, gives audible ticks which can be counted as the exposures are made, and is likely to be reliable. If a stop-watch is used, its rate over periods as long as an hour needs to be carefully checked against time-signals.

A simple timing technique is to begin and end the exposure on exact whole seconds by the clock, while the satellite is within the field of view, as in Fig. 1. This gives two timed positions, which are sufficient on one exposure. Extra timing breaks on the trail can be inserted if desired by covering the lens for timed intermediate periods. Alternatively the camera may be mounted on a pivoted steel plate which is displaced each second by a solenoid actuated by an electrical contact on the pendulum, such as a wire dipping into a blob of mercury. This method, suggested by Dr. Fred L. Whipple, gives a useful improvement in accuracy. Fig. 4 illustrates such a trail with timing marks. If a chronograph is available, the instants of timing marks may be recorded and compared with seconds impulses from a clock. A tape recorder can be used to record clock ticks as well as the instants of timing marks and any spoken comments. Whatever method is used, the times of exposures and the constellations included in photographs should be noted down as soon as the satellite has passed. It is well to practice the routine in advance.

An exposure of 10–20 seconds is usually enough to give a clear trail and sufficient star images; if longer, star images will be trailed and background fog may develop. Evidently the timing accuracy will be most effective when the apparent motion is greatest, that is, when the satellite is at the highest point of its path and closest to the observer. When low and distant, moving almost along the line of sight, the apparent motion is small; it is only about 1° in the 10-second exposure Fig. 3, which is reproduced to the same scale as Figs. 1 and 2.

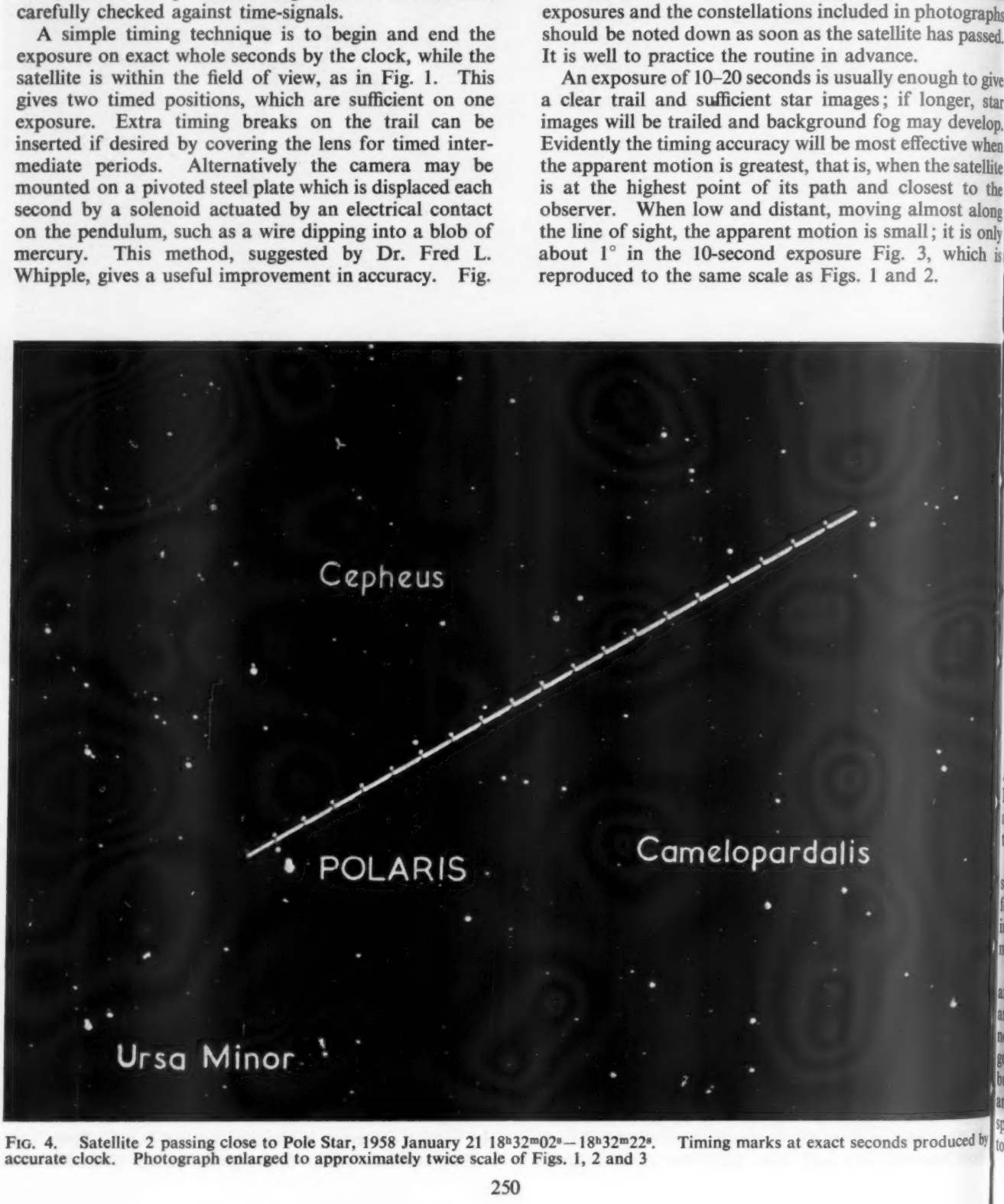


FIG. 4. Satellite 2 passing close to Pole Star, 1958 January 21 $18^h32^m02^s - 18^h32^m22^s$. Timing marks at exact seconds produced by accurate clock. Photograph enlarged to approximately twice scale of Figs. 1, 2 and 3

Measurement

It is often easiest to identify the brighter stars from a print or enlargement, especially if the enlargement is made to the same scale as the star atlas used. Then the satellite trail can be plotted on the atlas, using stars on or near the trail as reference points, and the co-ordinates (right ascension and declination) of the known timing points measured by means of the scales of the atlas. A more reliable method is to put the negative in an enlarger and project directly on to the atlas, adjusting the magnification so that the star images fit their counterparts in the atlas. Fitting may be possible only for a small region at one time, so that stars near the trail should be used. Also arising from the differing "projections" of the photograph and atlas, the trail may be curved when plotted on the latter.

Many amateurs possess the popular *Norton's Star Atlas*, but this is limited to the 6th magnitude and the scale is small, 1° = 3 mm. The somewhat more expensive *Atlas Coeli 1950.0* (Czechoslovakian Academy of Sciences) is excellent for plotting satellite trails; it shows stars down to 7·5 magnitude, the scale is 1° = 7·5 mm., and a transparent grid for position measurements is included.*

Data Centres

Photographic positions are required, for final analysis of the orbit, by the Astronomical Council, Academy of Sciences of the U.S.S.R., Moscow D-56, Bolshaya Gruzinskaya 10; by the Smithsonian Institution Astrophysical Observatory, IGY Optical Satellite Tracking Program, 60 Garden Street, Cambridge 38, Massachusetts; and by Miss D. M. C. Gilmore, Guided Weapons Dept., Royal Aircraft Establishment, Farnborough, Hants. It is possible that observations will eventually be collected by official IGY data centres, but at present those listed act independently.

The data centre must be informed of the observer's latitude, longitude and altitude. After identifying the object (Rocket 1, Satellite 2, etc.), date and times are given as G.M.T. (0–24 hours) to the nearest second (or tenth, if genuine). Right ascensions (hours, minutes and possibly tenths) and declinations (degrees and tenths) are quoted *for a definite epoch* (usually 1950.0) of the atlas used. A note as to the stellar magnitude of the object is useful, if this was noted at the time of observation.

Finally, if an observer is unable to measure his photographs, the Smithsonian Institution are prepared to reduce any films sent to them for measurement.

* *Obtainable through Interplanetary Publishing Co., 12, Bessborough Gardens, S.W.1. Price £3.*

Astronautical Societies of the World — 1.

NORSK ASTRONAUTISK FORENING
(Norwegian Astronautical Society)

By Ing. KARL H. HÖIE, Secretary

The Norwegian Astronautical Society was founded on August 2, 1951, under the name of the Norwegian Interplanetary Society; later on the name was changed, as we found that "Astronautical" better encompassed the various studies of interest to our various members.

Like the British Interplanetary Society, our membership includes all types of interested persons—professional scientists, engineers, and the ordinary man in the street who has taken an interest in astronautical matter as well as in our more special subjects.

The aim of the Society is to seek to give our members and other interested persons and bodies the latest news and information available at all times, conveying both news of professional developments and of a more general nature. To further this end, we have a modest but fairly valuable library at the disposal of our members, and we hold regular meetings, with lectures by various specialists. We also try to give as much time as possible to holding lectures with other societies, thereby furthering our common knowledge, as well as obtaining new supporters.

Today our membership is made up mainly of professional scientists and engineers, though we have experienced a tremendous increase in popularity due to the recent developments in astronautics. The headquarters is at Storgaten 37, Oslo, and from time to time a Journal is issued. The present executive committee is as follows:

President: Cand. real. Ö. Hauge.
Vice-President: Dr. philos. S. O. Sörensen.
Secretary: Ing. Karl H. Höie.
Treasurer: Ing. A. M. Berggreen.
Librarian: Ing. J. Nicoll.
Other members: Cand. mag. Per Maltby, Siviling. E. Risberg.
Deputy substitutes: Dr.-ing. H. C. Christensen, Siviling. T. Krog.

STOP PRESS! By "Ursus"

Some people expected that 1958 would start with a bang, and were quite disappointed when it was ushered in with no more than a couple of whimpers. (The bang, in the shape of the American satellite, did not come until later.) In the first days of the New Year the only thing which really happened was that Sputnik I, now apparently known more officially as 1957 Alpha, came down—or, at least, it ceased to orbit the Earth. However, matters warmed up by January 7, when the Press reported that Russian scientists had sent up a man to a height of over 150 miles, and had even brought him back again. The *Daily Telegraph* wrote:

"The Soviet Union has launched an experimental rocket 160 miles into the atmosphere with a man aboard, reliable sources here [Moscow] stated last night. The man aboard the rocket parachuted successfully to Earth, the sources said. . . . Just how the Russians succeeded in the feat of getting a man back to Earth from 160 miles up was not made clear in the reports circulating in Moscow. Observers speculated, however, that the man was released from the rocket in a pressurized container. At the right stage, he would presumably parachute out to safety. The reports say he landed in the Soviet Union."

The *Daily Express* improved on the *Telegraph* figure by quoting a maximum height of 186 miles, and also quoted an anonymous American Air Force officer as saying; "Pipped again. We have been working on this, but we certainly cannot match it yet."

A few days more, and the value for the maximum altitude would certainly have risen well beyond the 200-mile mark; unfortunately the Russians themselves seemed to know nothing about this remarkable achievement, and were indeed rather amused about it all. Moscow officials pointed out that had the experiment really taken place, at least some mention of it would have been made in Soviet newspapers. It has been suggested that the story may have been started by a Moscow showing of a science-fiction film called "The Road to Interstellar Space" . . . .

Hardly had Whimper No. 1 (should it be Whimper 1958 Alpha?) died away when No. 2 was upon us. This time it came from Finland, where it was reported that the State Radio had picked up signals from a third Sputnik. London papers stated that a B.U.P. correspondent in Helsinki had heard the signals, and described them as the familiar "Bleep! bleep!" while confirmation came from West Germany and from a Norwegian coastal broadcasting station at Tjömö. The London *Evening News* of January 11 carried large headlines: "Sputnik III Riddle. Fresh Signals are Picked Up. Calls Heard—Then Fade."

It was left to the B.B.C.'s listening post at Tatsfield to solve this new mystery. Officials there first said that they could not identify the signals, but later they announced that they were sure the culprit was an idling teleprinter. The bubble was finally pricked by the Swedish radio, which found that the teleprinter had become tired of bleeping and had started transmitting messages in ordinary Russian.

The announcement of the successful Explorer launching by Wernher von Braun and his team came on February 1. The tidings had already been relayed to President Eisenhower (who was spending the week-end in practical experiments involving small guided missiles powered by drivers, niblicks and cleeks), and before long they had become headline news all over the world. Unfortunately there was no official comment from the Astronomer Royal, Dr. Richard Woolley, and since the American satellite was not observable from Britain it did not really matter whether Herstmonceux closed down for the week-end or not. The front pages of the newspapers were suitably impressed, as the following examples of main headlines show:

Ike's Honky-Tonk Moon Hurtles Round Earth. (*Evening News*, February 1.)

Ike's Sputnik Going Strong at 18,000 m.p.h. (*Evening Standard*, February 1.)

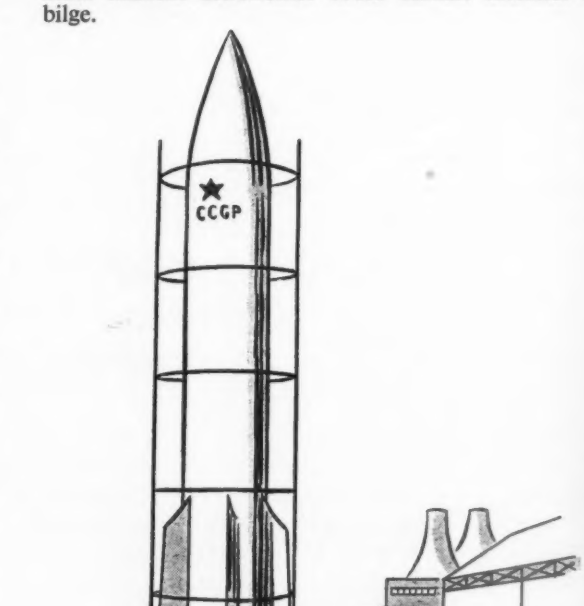
Ike's Moon Doing Fine. (*Sunday Express*, February 2.)

My Love for ******* ******—by The Boy with the Gun. (*Sunday Pictorial*, February 2.)

(In the last quote, the name of the film actress concerned was naturally given, but is replaced here by a row of other stars, for reasons of delicacy.)

The Vanguard launching which followed at a later date was not quite so successful. Apparently the rocket took off in the approved style, but then "deviated to the right" and so had to be blown up. It is however understood that this deviation was of scientific, not political, origin.

Unfortunately the surge of Press interest was hardly maintained, and before long the trifling news of the satellite launchings was relegated to a back place in favour of much more important matters such as a couple of murders, a police trial, suggestions of a routine bus strike, and some rowdy scenes in the House of Commons which gave the present writer a feeling of dull hopelessness. However, the inescapable fact was that Eastern-launched vehicles had been joined by a newcomer sent up from the West, so that not even the most eminent astronomer could dismiss satellites as utter bilge.



"And in a matter of minutes, Dr. Woolley, the Sputnik will leave the earth's atmosphere and penetrate Utter Bilge."

Reproduced by courtesy of PUNCH

A Test and Launching Stand for the Vanguard Rockets

By DON KARSHAN

The art of designing and manufacturing rocket and missile launching stands is relatively new and most of the data accumulated to date are veiled by security regulations. The article that follows, however, describes for the first time some of the design problems and solutions involved in the production of a combination test and launching stand for the Vanguard earth satellite rockets.

Project Vanguard, as widely known, is being directed by the Office of Naval Research in support of U.S. participation in the International Geophysical year 1957–58. Several three-stage rockets bearing the name "Vanguard" will attempt to place satellites in orbits around the Earth.

The historic launchings will take place at the Air Force Guided Missile Testing Centre at Cape Canaveral in Florida. The successul propelling of one of these small spheres into its orbit (at a speed of 18,000 miles per hour) would be the result of a vast scientific and engineering effort drawing on the most advanced technological resources of the nation.

DON KARSHAN

Don Karshan, who lives in New York, is a professional publicist specializing in material requirements and performance of missiles and rockets and their support facilities, as well as problems concerning the forming of high temperature metals. He is a member of the public relations staff of the G. M. Basford Company, and is well known for his numerous writings, illustrations and photographs in the rocket field. He witnessed the firing of the first Vanguard Test Rocket at Cape Canaveral, and this, plus his close association with Vanguard engineers, led to the preparation of the present article. He is a member of the British Interplanetary Society

A set of giant rockets (72 ft. long), each with three separate engines, fuel tanks and other complex components, is needed to transport the instrumented spheres into the fringes of outer space. To test the finished rockets prior to flight-firing and actually to launch them requires an equally complex and exacting ground support system. The success or failure of launching a vehicle as large, as heavy and as power-packed as Vanguard would depend in no small measure upon the efficiency of the testing and firing stand from which the rockets would "take off".

The creation, therefore, of a Vanguard stand was a critical project in itself involving design modifications, new devices, detailed refinements and severely exacting material specifications.

The stand would have to perform the following tasks:

1. Balance the rocket in a vertical position.
2. Hold down the rocket and protruding engine while the engine performs at peak thrusts.
3. Simultaneously measure these thrusts for performance data.
4. Tolerate the high temperatures and thrusts encountered during the prolonged static-firings.
5. Weigh the rocket and its fuel.
6. Channel and divert the rocket engine's exhaust blast.
7. Allow the rocket to free itself from its moorings in such a way that it may ascend correctly into flight path.
8. Extinguish any fire arising from engine mishap, etc.
9. Afford complete safety for personnel.

The Martin Company, prime contractor for Vanguard, gave Loewy-Hydropress Division of Baldwin-Lima-Hamilton a basic design concept for a stand that would meet all of these requirements. Loewy-Hydropress was given the sub-contract to refine this design and manufacture and install the versatile stand. After the many months that went into design modifications, fabrication and shop assembly, the completed stand was on its way to Cape Canaveral, Florida, for operational test-runs and first- and second-stage firings.

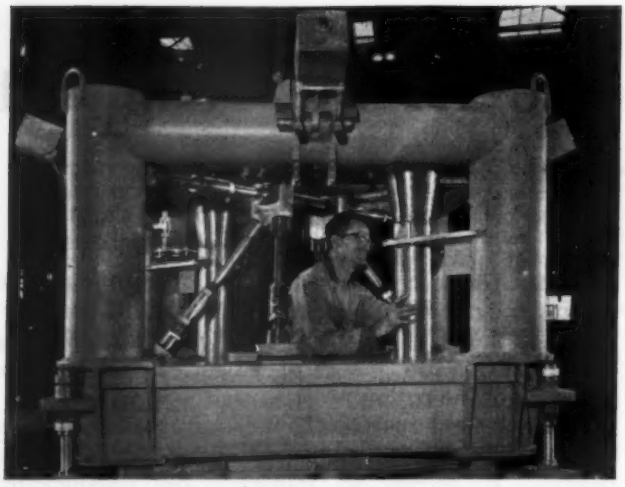


FIG. 1. Close-up of stainless steel portion of earth satellite launching vehicle rocket stand. Workman is adjusting jet deflector tube into place during assembly. Engine hold-down stainless steel tripods have already been mounted

Here are some examples of how Loewy-Hydropress and Martin engineers tackled the design problems posed by Vanguard. Working from the ground up, these are the basic components of the stand:

1. *Testing and Flight-Firing Structure.* This structure houses an ingenious water-cooled flame-deflector tube located below the top working deck. Purpose: to divert the exhaust blast.
2. *SR-4 Load Cell System.* The system is attached to a weigh-ring placed on top of the working deck. Purpose: measures thrust and weighs the rocket and fuel.
3. *Rocket Stand.* The stand is located on top of the load cell system. Purpose: to support the rocket and engine hold-down members and to house the deflector tubes.
4. *Jet Deflector Tubes.* These are within the Rocket Stand itself. Purpose: to confine and control jet roll blasts from rocket during tests.
5. *Engine Retention Tripods.* The tripods are within the Rocket Stand. Purpose: to hold-down the first-stage engine.
6. *Swing-Away Units.* These are positioned on top of Rocket Stand. Purpose: to hold-down rocket during static-test, and to swing clear during flight-firing.

The following is a detailed description of each of these components:

Static and Flight-Firing Structure

This structure is actually a nest of two units. The inner unit holds the flame-deflector tube and the outer, about 20 ft. square, holds the working deck or platform which supports the rocket stand. Both units are connected to a concrete pad by sunken bolts. The platform of the outer structure is made of 2-in. thick steel plate covered by a $\frac{1}{4}$-in. checkered steel plate. There is a gradual sloping to the centre of the deck where an opening leads to the flame-deflector tube. In this way any spilled propellents and other liquids are drained off and travel down the tube. Other interesting refinements include the emergency fog nozzles that extend over the platform and release a high-pressure mist spray in case of fire as well as emergency eye wash stands and a safety shower for personnel.

The large curved flame-deflector tube or throat is somewhat of an innovation in stand design technology. Its purpose is to divert the rocket's blast from a vertical to horizontal direction over the concrete pad. To withstand the high temperatures and thrusts exerted by the rocket's exhaust, the tube is water-cooled under high pressure through hundreds of tiny holes drilled through its walls. The structure housing the tube also contains the plumbing, flexible hose and manifolds required for a water-cooling system. Since the tube vibrates during firing, it is structurally isolated from the rocket stand. This was necessary because the load cell system on which the rocket stand rests is sensitive to and would record these vibrations, thereby interfering with other measurements.

Rocket Stand

The operating heart of the installation is the rocket stand; a $6\frac{1}{2}$ ft. square steel structure made of 8- and 12-in. pipe and stress relieved structural steel. All small carbon steel parts are cadmium plated to prevent rust.

It is by means of the rocket stand that the installation is able to serve as a true static-testing facility. Thorough testing requires the weighing of the rocket and fuels and the evaluation of engine performance, notably engine thrusts. The vehicle must demonstrate that it can develop the required thrust and that its engine will burn for the required time. Thus a hold-down and thrust measuring-weighing system was developed. The stand not only static-tests but will also launch Vanguard. In

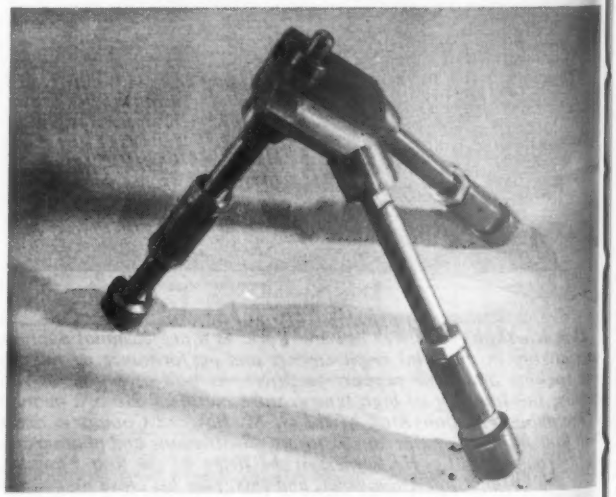


FIG. 2. Stainless steel engine—retention tripod for earth satellite launching vehicle rocket stand

the past, two separate facilities were needed to accomplish these tasks; a testing installation and a launching platform and pad.

SR-4 Load Cell System

Four 10,000 lb. capacity Sr-4 load cells and a massive connecting weigh-ring base were supplied to Loewy-Hydropress by the Baldwin-Lima-Hamilton Corporation's Electronic and Instrumentation Division, Waltham, Mass. These load cells are the ultra-linear type, accurate to $\pm$ 0·1 per cent. This is far more precise than conventional strain gauges.

One cell is placed under each corner of the rocket stand. The stand literally rests on the four cells which are mounted on the weigh-ring. This strain gauge system will measure thrust during static and flight-firing and will weigh the rockets as they are fuelled up. The approximate total weight of the Vanguard rocket will be 22,000 lb.—first stage: 17,800 lb.; second and third stages: 4,770 lb.

A few explanatory words on strain gauges may be helpful at this point. The widespread growth and application of experimental stress analysis can be credited almost entirely to the advent of bonded wire resistance strain gauges. These gauges work on a rather simple principle: It was found that electrical resistance of certain wires vary with the tension to which they are

FIG. 3. Ready to hoist one of the stainless steel jet deflector tubes into position for mounting in earth satellite vehicle rocket stand. Workman in background is securing second tube in place

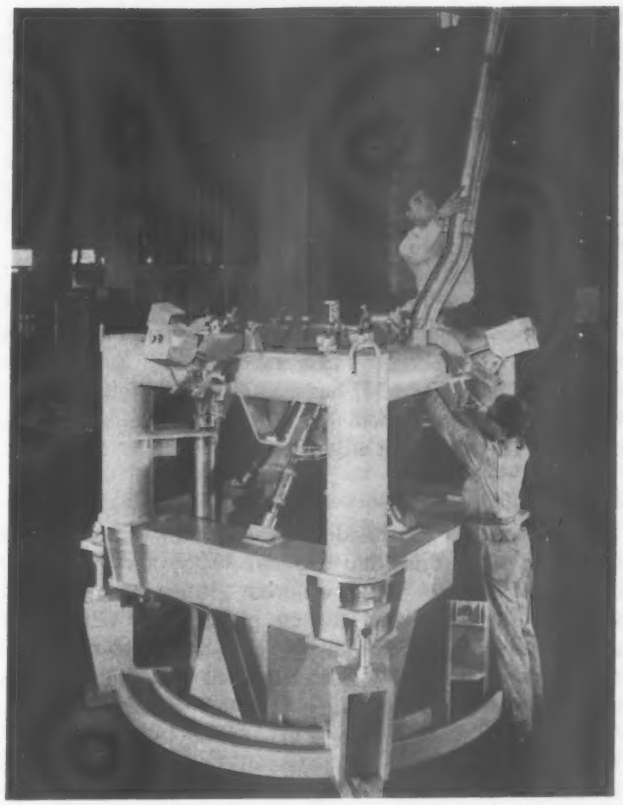


FIG. 4. Lowering stainless steel jet deflector tube into place in earth satellite launching vehicle rocket stand. Swing-away rocket hold-down mechanisms are visible on top of stand

subjected. This change in resistance, when detected by the proper instruments, becomes an accurate measure of the strain in the wire (and hence, the strain in the underlying material). Thus, the strain gauge load cell serves as a compression-force-measuring unit. It can determine the unit strength of loads, torque, pressures, vibrations, etc. Another characteristic of the load cell is its insensitivity to bending and temperature variations. It is only sensitive to axial loading.

The Baldwin-Lima-Hamilton strain gauge load cell is fabricated in the form of a solid column with the strain gauges on the surface. The ends are capped and the lead wires taken out for remote indication or recording. Suitable instruments are necessary to receive the electrical signals. These signals are proportioned, through a non-calibration factor, to the strains being measured. Finally an interpretation of these strains is made for accurate corrections in rocket performace control data.

In the Vanguard site this instrumentation, part of the total weighing system supplied by the Electronic and Instrumentation Division of Baldwin-Lima-Hamilton, is located in the heavily walled concrete block house and in the equipment house near the stand.

Jet Deflector Tubes

Two all stainless steel jet deflector tubes, within the rocket stand divert the high pressure steam blasts from the rocket's small rotating jets located near the bottom of

Vanguard. The steam created by the action of hydrogen peroxide, reached a temperature of about 800°. The jets are capable of being rotated in less than 1/10th of a second by means of solenoid-controlled pneumatic actuators. They help control, by causing a compensating reaction, any lateral motion or "roll" that the rocket develops. The steam blasts travel down through the rocket stand's two deflector tubes into the main flame-deflector tube below the deck of the structure.

The deflector tubes are made of 16 gauge, type 347 stainless steel. This type is generally chosen for welded applications subject to corrosion and heat and also when mechanical properties must be retained at elevated temperatures. Type 347 has been used for high temperature applications such as airplace exhaust stacks, collector rings, and jet engine parts.

Engine Retention Tripods

Connected to the inside of the pillars of the rocket stand are two adjustable tripods. They are also made of stainless steel. Three different grades were chosen; type 303 for the screws and couplings, type 420 for the studs, and type 304 for the yokes. The purpose of the tripods is to hold down the extended first-stage engine, designed and manufactured by the General Electric Corporation, Utica, New York. The two tripods are joined in the centre of the stand by two solid forged blocks of stainless steel designed to connect to the gimbal ring of the extended engine by means of a pin. Although the swing-away units hold the rocket, it is important that a separate hold-down force be applied to the engine itself. The entire tripod system is removed from the rocket stand during flight-firing.

Vanguard does not use fins to stabilize the vehicle's motion in flight path. Instead of fins a system was chosen whereby the protruding section of the first-stage engine—the exhaust nozzle and other units—are set into motion in a gimbal and act as a substitute stabilizer. Servomechanisms activate this gimbal, creating what is claimed to be far more efficient stability than that resulting from the fixed fins of the past.

Swing-Away Units

Four self-removing retaining devices are located on top of the rocket stand, each centred on a cross tube connecting the stand's four pillars. These units are of the swing-away type and use a simple counterweight and spring system. Their functions are to hold-down the rocket itself and to brace the rocket temporarily prior to flight-firing. The four units will swing out of way of the vehicle at the moment of firing so as to clear the gimballed engine as it passes by. The retaining devices are made of various types of carbon steels with the exception of the main pins which are type 440 stainless steel, heated to 400 Brinnell. One of the reasons stainless steel was chosen was to prevent rust from forming on the pins, thus slowing down the motion of the units. The other reason was toughness. Due to its high carbon content, type 440 is one of the corrosion-resisting steels which can be heat-treated to the highest hardness. This grade is often chosen for ball bearings, cutting edges, shear blades and other applications where the best possible combination of high hardness and corrosion-resistance are required.

Thrusts and Temperatures

The rocket stand and testing and flight-firing structure were designed to withstand 90,000 lb. of thrust. This represents a substantial safety factor of three to one since the first-stage engine is not expected to develop thrusts in excess of 30,000 lb.

The rocket stand components are specified to withstand, for short duration, a temperature of 5,000° F. The first-stage engine is expected to generate a temperature of approximately 4,000° F. Static-firing of Vanguard will probably involve sustained intervals up to a minute. During the 5 seconds generally predicted for the Vanguard rocket to deliver sufficient thrust to clear the stand area the surrounding steel of the rocket stand is expected to reach a temperature of 1,000° F.

The Vanguard Blockhouse

Security regulations do not permit descriptions of some other aspects of Vanguard's ground support system. The air-conditioned blockhouse, for example, standing almost within the shadow of the rocket is crammed with complex instrumentation. It is here that the signals

FIG. 5. Close-up view of stainless steel jet deflector tube for earth satellite launching vehicle rocket stand

from the stand's load cells record their measurements. The "brain" of the ground fire control system is located in the blockhouse and the long procession of "count-downs" that trigger the entire operation into action originates here. It is in the blockhouse that scientists and technicians will peer through layers of green-tinted glass to observe the firings.

They will see a giant Vanguard rocket, looking like a huge acetylene torch burning into the launching stand. The rocket will be unleashing a fiery blast for 40 seconds or more amid the spray of thousands of gallons of water engulfing the open throat of the flame deflector tube. The 72-ft. high rocket will strain at its moorings—wanting to be skybound—as peak thrusts are reached. This will be one of the longest static-firings.

To the observer watching this event the ruggedness of the relatively small stand (about the size of a boxing ring) will be most impressive, and deservedly. The repeated punishment it will receive under the relentless blows of many test-runs and the long series of Vanguard flight-firings (at least six attempts) will be a graphic testimony to the stand's sound design and materials.

It is significant that one of the most critical areas of the whole installation—the centre of the rocket stand—is fabricated from stainless steel. The jet deflector tubes, the engine retention tripods, the main pins of the swing-away units—all are made of various grades of stainless steel, each chosen to meet a particularly strenuous set of conditions.

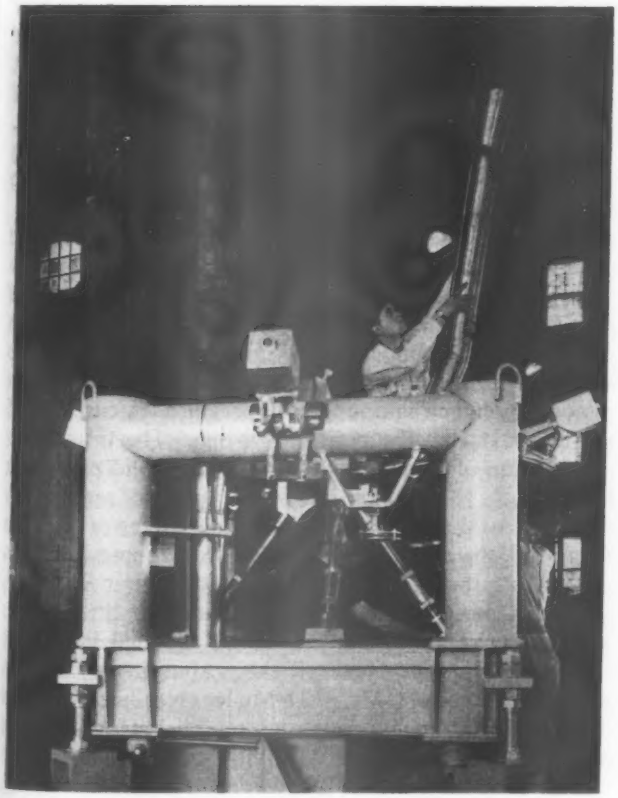


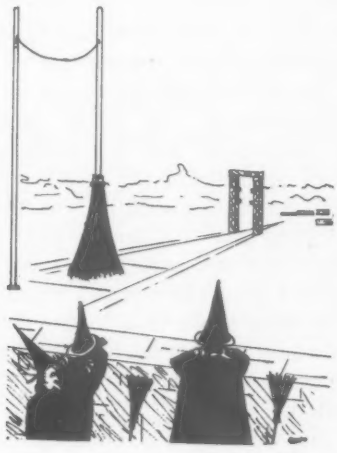
FIG. 6. Lowering stainless steel jet deflector tube into place in earth satellite launching vehicle rocket stand. Swing-away rocket hold-down mechanisms are visible on top of stand

The Rockets and Satellites

Stainless steels are, of course, used in the rockets themselves. No information is available on metals employed in General Electric's engine but it is safe to assume that the exhaust cones and areas of the engine linings and rings are of stainless. The first-stage propellent tanks are of welded aluminium. The tanks for the second-stage are of a precipitation-hardening grade of stainless steel. This grade was required because the fuels for this stage are high corrosive. The rest of the second-stage skin is magnesium-thorium. The after portion of the second-stage, including the engine thrust chambers, tanks and plumbing, was built by Aerojet General Corporation, Azusa, California. The nose cone of the third-stage is constructed of a moulded asbestos phenolic material with a titanium tip. For the satellites, strength of material was not so much the issue as weight. The 20-in. diameter spheres will weigh-in at 21½ lb. each, fully loaded. The lightest possible metals were therefore chosen, such as magnesium and aluminium.

With the launching of Vanguard and the successful orbiting of a satellite, man will have launched himself into a virtual new age of exploration and investigation in outer space. The chronology of his march to inter-planetary travel has been described as: (1) Unmanned satellite (Vanguard); (2) manned orbital glider; (3) permanent space station; (4) space ships; (5) inter-planetary flight.

Some of the items of high scientific import that are slated to be investigated are: Upper air densities, temperatures and pressures; ultra-violet, cosmic, and X-ray radiation; Earth's reflection of sunlight, causes and formation of weather cycles; and the Earth's atmosphere and magnetic field. The greatest scientific achievements resulting from the satellite may be those not as yet anticipated.



R. D. Miller

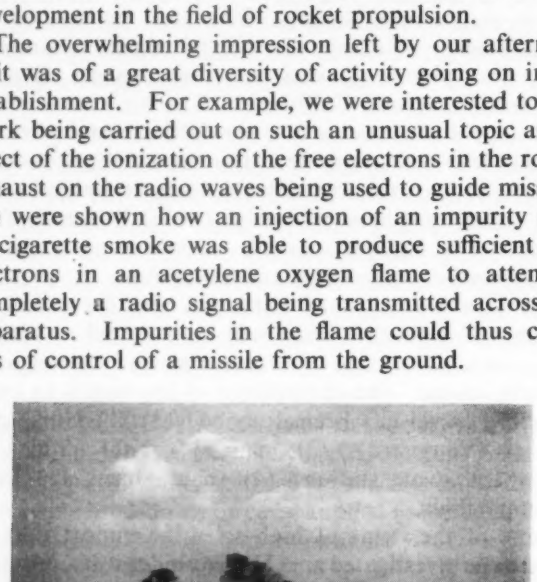
Rocket Research in Britain

OPEN DAY AT WESTCOTT

Reported by MAURICE ALLWARD

In the absence of Mr. J. E. P. Dunning, the Chief Superintendent, the party was welcomed to Westcott by Lieutenant-Commander W. E. D. Hull, who explained that the work of the establishment was research and development in the field of rocket propulsion.

The overwhelming impression left by our afternoon visit was of a great diversity of activity going on in the establishment. For example, we were interested to find work being carried out on such an unusual topic as the effect of the ionization of the free electrons in the rocket exhaust on the radio waves being used to guide missiles. We were shown how an injection of an impurity such as cigarette smoke was able to produce sufficient free electrons in an acetylene oxygen flame to attenuate completely a radio signal being transmitted across the apparatus. Impurities in the flame could thus cause loss of control of a missile from the ground.



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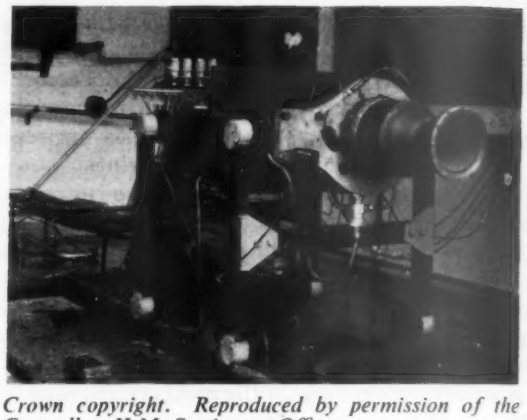
The Metallurgical Laboratory had on view parts from a number of rocket motors which had failed. Some of these failures indicated that stresses can be produced as much by the attempt to cool motors as by the effect of the motor combustion. Of equal interest to the Metallurgical Laboratory was the Laboratory dealing with the use of refractories for rocket motor casings. Here the most interesting exhibit was the attempt to produce something like a solar furnace by mounting two searchlight mirrors opposite to each other, the second mirror bringing the parallel beam produced by the first mirror back again to a focus. In this manner sufficient heat could be generated at the second focus to enable experiments to be performed on the melting of refractory materials.

Much of the work in the chemical laboratories is devoted to improving the stability of H.T.P. (High Test Peroxide, containing 80–90 per cent. pure hydrogen peroxide). Experience has shown, however, that stabilizers sometimes produce adverse effects on the catalytic screens (usually composed of metallic silver deposited on nickel gauze), and these still require a good deal of experimental work. Related research on the effect of H.T.P. on other materials is yielding information of value in the construction of couplings and fuel tanks. The use of P.V.C. and polythene is showing promising results and is particularly interesting because of the extreme lightness of the resulting product.



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The highlight of the visit was, of course, the static firings of solid and liquid propellant rocket motors. The first item on the programme was the static firing of an 8 ft. long solid propellant motor of the type which might be used to boost guided missiles. The motor was mounted horizontally, and on firing pressed against a piston which, acting upon an oil pressure system, showed the thrust during the period of firing. The thunderous combustion of some hundred-weights of solid propellant in precisely 3 seconds produced a most satisfactory initiation to the power of these oversize fireworks. The firing of the liquid fuel rocket was somewhat less successful; the first attempt, assisted by our Secretary, yielded a most spectacular flame but very little thrust. Len Carter's excuse that he hadn't touched it yet was treated with the usual ribaldry that such remarks generally receive. Mr. K. Meiler reminded us that Westcott was an experimental establishment and that such semi-failures were carefully analyzed and often yielded valuable data. In this case the failure appears to have been caused by the extreme volatility of liquid

[*Continued on p. 260*

Sky Diary: April to June, 1958

By A. E. SLATER

Some of those bright stars of the southern sky in winter still linger on in the west in the early evening, and even in June the "Twins", Castor and Pollux, may be seen setting in the north-west soon after sunset. Almost overhead is Ursa Major, the Great Bear or Plough, whose shape very slowly changes through the centuries, as shown in "Sky Diary" a year ago.

Two conspicuous reddish stars hold the attention in the southern half of the sky during this period, one high and the other low; both, if you could approach them, would appear large and diffuse—qualities which account for their redness. Arcturus, the higher one, can be found by extending a line through the tail of the Great Bear and giving it a slight droop. Just 100 years ago, in 1858, the brilliant nucleus of Donati's Comet passed directly in front of Arcturus without diminishing the brightness of the star. Seen from the Solar System against its background of more distant stars, Arcturus is moving unusually fast. Seen from close to, it would show a diameter of some 30 million miles, giving it about 43,000 times the volume of the Sun, though it has only 12 times the solar mass and 100 times the luminosity. According to Cecilia Payne-Gaposchkin, Arcturus has a life expectation of 50 million years, so it is a short-lived object on the cosmical scale, and the dinosaurs probably did not see it! A life-bearing planet of Arcturus would, it is estimated, have to keep as far from its centre as Saturn is from the centre of the Sun.

The lower of the two red stars, Antares, is so called because its bright, ruddy light rivals that of Mars, the Greek god being not Mars but Ares (hence areography is Martian geography, and the first space-travellers to land there will get busy with their areodesy). Mars was close to its rival at the beginning of January this year, but has moved well away by now, and is still only to be seen in the early morning. Antares, on the other hand, rises in the south-east before midnight in mid-April and at 8 p.m. in mid-June, and is to the south, still very low, three hours later, in the company of several other bright stars of the constellation Scorpio.

The interferometer method shows Antares to be enormous—360 million miles in diameter—big enough to enclose the orbit of the Earth, and even that of Mars. But it has no more than 30 times the solar mass, so it must be only 1/700 as dense as Arcturus; nevertheless it has a high temperature. At its present rate of turning mass into energy, it could live for a mere 6 million years.

During early spring, the line of the ecliptic, near which the Moon and planets move as they follow their orbits, goes up steeply from the setting Sun, and the thin crescent Moon can be first sighted at an earlier stage of its waxing than at other seasons. Some people claim to have seen it only 19 hours after it has been "new" (i.e., passing this side of the Sun), and I believe the record is 14 hours. On April 19 the Moon is new at 03 hours 23 minutes, so at sunset, which is at 7.3 p.m. (G.M.T.) in London, it will be 15 hours 40 minutes old, while at sunset the next day its age will be 39 hours 42 minutes. At sunset on May 20 its age will be 24 hours 54 minutes.

When the sunlit portion of the Moon appears as a thin crescent, the rest of it is faintly lit by sunlight reflected from the Earth—in this case mainly from clouds over the Atlantic Ocean and the Americas; and of course the strength of the light varies with the total amount of cloud. We thus obtain a second-hand view of the Earth's cloudiness, as seen from the Moon, which we must be content with until we can get a first-hand view.

The single eclipse of the Moon this year, a very "partial" one on May 3, can be seen only from the other side of the world. Nevertheless, it is not generally realized that one can see the shadow of the Earth without having to wait for a lunar eclipse. All that is necessary is a clear sky after sunset, and now that those readers who work regular hours in offices will be getting home in time to see the Sun go down, opportunity may be taken to see the shadow cast by the Earth on our own atmosphere. You must look to the east or south-east, opposite the Sun, and at first all you will see is a pinkish glow just around sunset time. But soon a dark band appears beneath the pink, and its border rises upwards as it thickens; this is the "first Earth shadow", and is cast by the Sun on the atmospheric haze in the east. The upper border of the shadow looks curved, partly because of the curvature of the Earth, but partly due to an optical illusion. The human eye was not designed to appreciate spherical trigonometry, and as any horizontal line above the horizon, if straight, meets the horizon at both ends, the eye sees it as an arch. Meteorologists, who ought to have known better, used to apply the word *arcus* (arched) to a perfectly straight band of cloud which sometimes marks the line of a cold front.

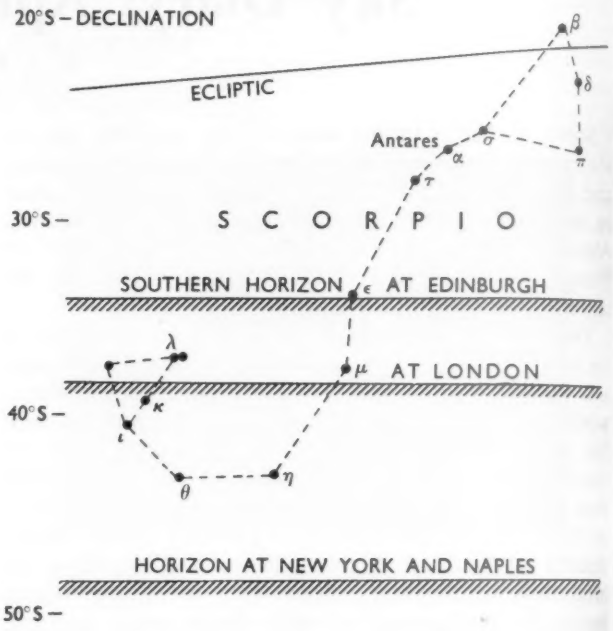
The "first Earth shadow" eventually passes overhead and then settles down in the west, and if you continue to watch the eastern horizon you should see the same phenomena repeated, though more faintly; these are caused not by the direct rays of the Sun, but by sunlight reflected from the upper atmosphere beyond the western horizon.

It seems probable that the shadow is cast upon the dusty troposphere, below the stratosphere, and certainly not upon the levels at which artificial satellites move. It

should therefore be possible to see a satellite through the shadow, and much more distinctly than through the pinkish area. It would be interesting to have satellite-watchers' observations on this point.

Jupiter is at its nearest in April, coming to opposition on April 16, when it will rise at sunset, be due south at midnight, and set at sunrise. There is no mistaking it, as it will be the brightest object in the sky (apart from the Moon) until Venus comes up in the east an hour before sunrise. By the end of June, Jupiter will be setting about midnight. Even a small telescope shows its equatorial cloud belts, its oval shape, and the constantly changing positions of its four large satellites. Some people claim to be able to pick up Jupiter with the naked eye around sunset, but for most it does not appear until the "first Earth shadow" engulfs it.

Saturn also comes into opposition during this period, on June 13, but is rather low down—little higher than Antares, which is some degrees to the west of it. The plane of Saturn's rings is now lying at the maximum inclination to the line of sight from the Earth. These rings must be made up of separate particles which are continually hitting one another, and would do the same to a space-ship which got among them. Although the rings appear to be very thin, there must be a few stragglers outside the plane, and the question of how near one could get to them in safety is not an easy one to answer.



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oxygen. This means that any liquid oxygen in the fuel pipes leading to the motor will, if left static for any length of time, rapidly boil and become gaseous. To delay this the oxygen-carrying pipes are usually cooled immediately before firing by blowing through liquid oxygen until liquid itself begins to emerge from the motor. It appears that this might not have been done on this occasion, with the result that the mixture was so fuel-rich that combustion took place entirely outside the motor.

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The second attempt, watched over but not materially assisted by a non-executive member of the Society, was entirely successful, producing an even louder noise than that of the solid propellant motor.

During the afternoon we were shown a film setting out the drill followed in the course of the firing of a liquid propellant motor. The film emphasized the safety checks which are carried out to ensure accident-free firings of these potentially dangerous objects. At Westcott, which has a very good safety record, the electric link at the rocket end of the chain is completed by two members of the staff whose duty it is to see that the rocket pit itself is clear of all other personnel. Red and yellow flags and an audible warning are used, and in the words of the official statement: "Not more than six persons are allowed in the firing blocks at the time of firing." How this is a safety precaution from the point of view of these six persons was not altogether clear, but it must be admitted that this limits the number of people that could be injured in any one accident.

Our visit ended with tea and a closing discussion in the conference room. Altogether the afternoon was excellently organized; the organization extending even to really fine weather following three days of thick fog.

Correspondence

SIR,—The precept "Do unto others as they would have you do unto them", The Rule of Metalaw proposed by Andrew Haley, appears to have aroused surprisingly little critical comment. It seems to me to be a highly dangerous approach to the problem of how to behave in the presence of an alien intelligence. Literally it appears to direct an Earthman to do whatever an alien desires. What should be done when an alien desires an Earthman to hand over his vehicle, his equipment and his crew? It is evident that the Rule of Metalaw would often be unworkable.

May I offer my own motto as a more suitable guide to behaviour? This is, simply, "Press on with regard."

Yours, etc.,

S. W. GREENWOOD.

The College of Aeronautics,
Cranfield, B.

SIR,—In his article "The Space Age is Here", Maurice Allward says the Russians called their satellite the Sputnik (meaning "fellow-traveller"). Sputnik *does* mean fellow-traveller, but in the astronomical sense it is just the ordinary word for satellite—the word they use for our Moon or for the moons of any planet. Sputnik is not a word the Russians have given to artificial satellites. When they want to differentiate between artificial and natural satellites they have to use the adjective "artificial" (iskoostvennei). And incidentally, Sputnik should be pronounced "Spootnik".

Yours faithfully,

G. E. B. STEPHENSON (Lt.-Col.).

124, Duchy Road, Harrogate.

SIR,—An article some months ago in *Interavia* recalled a book written towards the end of the nineteenth century in which a medium told of surface conditions, language, etc., of Mars. One of the sketches included with the article purported to be a Martian village and an interesting point about it was that each building apparently sported an anemometer.

I felt that some explanation was required and have now found one that appears to meet the case. Surface conditions on Mars include intense dust storms, and what more simple solution could be found than to fit an anemometer to each dwelling to operate at a predetermined wind speed a warning, and, after a lapse of time to enable the populace to seek cover, a device to close doors and windows and operate a filter or conditioning plant? When the wind dropped the mechanism would reverse the action.

Whether or not something like this happens on Mars, such a device would be useful at some places on Earth.

Yours faithfully,

E. CONRAD MILLER.

2, Helston Place,
Abbots Langley, Herts.

Reviews

Project Satellite. By W. von Braun, K. Gatland, H. E. Ross and A. V. Cleaver. Edited by K. Gatland. Wingate Press. 21s.

This book stands out from the recent crop of hurriedly prepared publications on the satellites. The information that it contains is in general accurate and well presented, and the text seems almost entirely free from typographical errors. The purchaser should, however, realize that at present he can learn very little about the actual satellites from this or any other book, because full and accurate analyses of their performance have not yet been completed.

Project Satellite does, however, provide a most interesting account of the historical development by von Braun, followed by a competent summary of the American satellite plans by Gatland. Four pages of this section are devoted to Sputniks 1 and 2. The book is rounded off by sections on the possible future development of orbital bases and manned interplanetary flight, by Ross and Cleaver respectively.

The differences in style between the four authors are acceptable and even refreshing, but there is some irritating repetition which could have been eliminated by sterner editing. In view of the high standard of accuracy it seems worth calling attention to the following technical points:

The appearance of the satellite on the dust jacket is not consistent with the laws of geometrical optics as applied to a polished spherical body.

P. 71. The description of the N.A.C.A. "fan tail" re-entry body does not make sense. Retracting the tail when the body encounters denser air will merely prevent the tail from being overheated, and the nose will be exposed to even more severe heating than if the tail were left open, because the tail no longer does its share of the braking.

P. 74. The provision of helium in the first stage tanks is to prevent a vacuum developing as the fuel is sucked out, with consequent cavitation in the pump. It does not "prevent build up of back pressure".

P. 80. In discussing the permissible errors in angle of elevation at which the third stage must be projected into orbit, the critical dependence on velocity of projection is not made clear. Moreover, there is no special penalty incurred by a negative angle of projection; both positive and negative errors are equally serious.

P. 111. It seems unlikely that the early provision of a pressurized assembly shop would help in building a space station. The initial assembly would consist of fitting together large prefabricated sections, which could not be done within a part of the structure. The subsequent fitting out of the interior would be done with the whole thing under pressure.

P. 114. Strobotelescopes may be an attractive engineering solution to the problem of observing from within a rotating space station, but they would probably be quite useless for serious astronomy.

P. 117 et seq. Mr. Ross has misinterpreted the results of tracer experiments in photosynthesis in maintaining that

plants and algæ do not recover the oxygen from CO_2. The evolved oxygen does come from water in the first place, but half of this water is itself supplied from the combined oxygen of the CO_2 when this is converted to carbohydrate, whilst the other half of the water is formed when the carbohydrate is "burnt" in the body. Thus the overall materials balance definitely allows one to maintain (in theory) a closed cycle without importing either oxygen or water. The practicability of keeping both life forms involved in good health has indeed yet to be demonstrated.

Apart from these few points the book presents as accurate and well balanced an account of this subject as could possibly be written at the present moment. It is recommended to all those who wish to obtain such an account.

C. A. Cross

Space Flight and Satellite Vehicles. By R. B. Beard and A. C. Rotherham. George Newnes, 1957. 150 pp., 12 plates. 15s.

This new book by two members of the B.I.S. is yet another addition to the field of popular literature on astronautics. The authors have attempted a wide coverage and appear to have aimed at the general reader with a moderate technical aptitude.

Unfortunately, there are a number of errors of a technical nature. The chapter on "Basic Principles", in particular, needs careful revision. S. W. Greenwood.

The Changing Universe. By John Pfeiffer. Gollancz, 1956. 244 pages.

Now that the science of radio astronomy has come so much to the fore, it is pleasant to find an introductory book written in a manner which can be easily understood by the layman. Pfeiffer has provided such a work. Typical chapter headings are "Exploring the Radio Sky", "The Sun in Action", "Mysterious Signals", and "Exploring our Galaxy". There is also some historical information—for instance, the career and work of the pioneer Karl Jansky is described.

Doubtless there will be other popular introductions to radio astronomy, but this is the first of them, and may well become the standard. The one fault is that Pfeiffer concentrates so much upon his own subject that the unwary reader may be led to believe that the "old astronomy", carried out by classical observational methods, will in time be superseded by the new methods—which is not, of course, the case.

However, this is an understandable fault, and in no whit detracts from the value of the book. It can be recommended without hesitation. A. S.

Practical Astronomy. By W. Schroeder. 200 pp., 17 plates, 76 diagrams. Werner Laurie. 15s.

In the days of Chaucer one learned the fundamentals of descriptive astronomy from the astrolabe. To-day interest is drifting from the methods of computation to the results, and most recent books on popular astronomy tend to encourage this. Ready-made planetary computation can be taken from the almancis and used by beginners without their full appreciation of the elegant methods used by the astronomer to obtain them. These methods when fully understood can be just as exciting as the discoveries to which they lead, but very few books emphasize this to the beginner. They cater either for the armchair astronomers or the man with the small telescope. Very few send the reader to the study table with ruler and compass, in order to master the fundamentals of astronomy, but Mr. Schroeder's new book *Practical Astronomy*, promises to do this. It is written in a lucid style: and the methods described are not beyond the student who has retained a rudimentary knowledge of his school geometry.

The book is by no means academic, in fact, it needs a little mental agility on the part of the reader to break away from conventional methods and adopt Mr. Schroeder's simplifications.

In the foreword we read that the aim is to disguise mathematical formulæ in simple graphs and diagrams. This has been attempted with a good measure of success.

Chapter 9 describes how a celestial globe may be constructed and used, without the reader being aware he is being gently led into the mysteries of conical orthomorphic projection.

The making and use of a nocturnal, astrolabe, quadrant and sundial are dealt with so that all but the careless will learn much during the construction.

The reader who attempts to make the small equatorial refractor described in Chapter 14, will learn much in the making, but it is doubtful if he will find such a small aperture of much practical use when he has made it.

The description of 140 interesting objects to be found in the sky should certainly form part of any book on Practical Astronomy.

The few minor errors or misprints that occur will in no case mislead the thoughtful reader, he will detect them and feel pleased he has done so.

The book is to be commended not only for encouraging one to think for himself, but for urging the combination of theory with practice. "To see with one's own eyes rather than through the eyes of others." E. H. Noon.

Looking at the Stars. By M. W. Ovenden. Phoenix House, London, 1957. 192 pp., 28 plates. 10s. 6d.

In this book, Ovenden sets out to present an up-to-date picture of the whole of astronomy to teen-age readers. On the whole he succeeds very well in this endeavour, and the book is excellent value as a present to any youngster who shows interest in astronomy.

Ovenden has mastered the difficult art of popular presentation, but there are a few places where the urge to present a simple and compelling story has led to over-simplification and definite error. Thus on pp. 115 and 116 he says that "the stars are in fact natural atomic piles", which is a misleading picture to plant in the young mind.

Similarly, in discussing the birth of a new star (p. 118) he does not allow it to start shining until nuclear reactions have started in its core. By omitting the contribution of gravitational energy he leaves the reader wondering how the core got hot in the first place.

The book provides plenty of sensible observational exercises, but it is a pity that one of the first of these invites one to find the brighter stars of the Plough and Cassiopeia on a photograph of trailed circumpolar star images which is too small to contain them.

In the section on the planets I found two extraordinary statements which need amendment.

On p. 84, explaining the absence of craters on Earth, "Any craters of this type would in a few million years be rubbed away by friction with the atmosphere as the Earth rotated underneath it".

On p. 86, discussing the spectroscopic method of determining rotation, "The reason that it fails on Venus is that we do not see the surface of Venus at all."

I feel sure that Ovenden does not really believe that planetary atmospheres remain stationary whilst the planets revolve inside them.

On page 136 the number of stars in the Galaxy is given as 10,000,000,000. Modern work has shown that the correct figure is much greater than this, and 100,000,000,000 is more probable.

Perhaps these minor defects can be put right in the next edition, for the book deserves to achieve popularity. The only misprint that I noticed was on p. 105. C. A. Cross.

The Inhabited Universe. By Kenneth W. Gatland and Derek D. Dempster. Allan Wingate, 1957. Price 21s. Many illustrations.

"An inquiry staged on the frontiers of knowledge": such is the subtitle of this book. So we expect to find a good range of subjects; but our expectations are likely to be exceeded, for those covered include astronomy, cosmology, atomic physics, the origin and evolution of life, time theories, telepathy, religion and some politics. We had better not discuss the last two beyond saying that the views expressed will be considered enlightened by those who agree with them. On the other subjects listed above, readers will find a wealth of information and, whatever their interests, are bound to come across much that is both interesting and new to them.

We start with a cosmological chapter "Worlds in Creation", followed by Chapter 2, "The Dawn of Life", which takes us from life's origin through the mechanism and course of its evolution. The next chapter, "Our Neighbour Worlds", is largely about Mars and possible life upon it: then, with "The Expanding Universe", after another glance at life we are back into cosmology, this time with some history of the subject's development, leading up to modern radio astronomy. With Chapter 5 we shrink mightily to discuss the structure of atoms, and in Chapter 6 we are concerned with light and make the acquaintance of Einstein, who stays with us through the next chapter on "The Time Paradox". But with Chapter 8, "Other Universes", we begin to leave mere conventional physics behind.

Up to this point the text has been written entirely by Kenneth Gatland, who needs no introduction to *Spaceflight* readers. But, he tells us, he became too busy to finish the book unaided and Derek Dempster collaborated with him over the last third of it. In this we are taken to see the miracle cures at Lourdes, introduced to extra-sensory perception and psychokinesis, and wander among religions, mysticism and political ethics. Here the strict materialist will find himself up against it: by what physical laws, for instance, can people see into the future, or move matter by merely taking thought? Or are these things just incredible? One is reminded of Eddington's suggestion that, when we think we have discovered something about the Universe, all we have really learnt is something about our methods of investigating it—in fact, we have done no more than look into a mirror.

It is apparent that the over-all purpose of this book, apart from giving information to those who hunger for it, is to integrate the phenomena of life with those of the physical universe. Whether they have been well and truly integrated must depend on the reader's point of view. At the one extreme we have the idea that life is as much a property of the universe as are its more material manifestations; the authors quote with approval Dr. Wendell M. Stanley as saying that "work on the viruses has provided us with new reasons for considering that life as we know it does not come into existence suddenly but is inherent in all matter". At the other extreme is the view that life is a sort of disease of matter that has broken out on the surface of one particular planet; on this view, which would horrify the authors, space flight becomes an attempt to spread the epidemic throughout the Universe, and d—n the consequences.

The reviewer's outlook comes somewhat nearer the second of these extremes than the first, though this is not said to discourage anyone from reading the book and drawing his own conclusions. Take, for instance, the statement on page 69 that "if life had not evolved in the way it did upon the earth, it would have found an alternative route and expressed itself in some other way"; and the information on page 66 that some bacteria live on sulphur and others flourish in a saturated solution of boric acid. Nevertheless, all these bacteria with queer chemical habits (and there are many kinds) are based on the same fundamental molecule as all other living things, that of deoxyribosenucleic acid (called DNA for short). This molecule is believed to act as a template for the formation of the proteins which control the development of living organisms; it is a very long molecule, and its detailed structure, which is variable, determines which particular proteins will be formed and consequently what kind of organism will result. Moreover, DNA has the ability to produce an exact copy of itself; it is the substance of which genes, the carriers of heredity, are made. Whether or not there are other molecules which could perform the same functions, the fact remains that they have not done so on the Earth.

As to viruses, most of them are based on ribonucleic acid (RNA), which can, like its near relation DNA, also serve as a template for forming proteins, but is unable to reproduce itself. Such viruses can, however, multiply as soon as they have infected a suitable organism containing DNA. It seems incorrect, therefore, to regard viruses as occupying a half-way house between living and dead matter; rather are they next-door to living matter, and the gap between them and inorganic matter is huge and so far unfilled.

J. B. S. Haldane has recently come to the conclusion that the Earth may be the only inhabited planet in the whole Universe; he reasons that even the simplest living organism must consist of a large number of proteins capable of interacting in such a way as to make the organism develop and work (i.e., not just any old proteins), together with a DNA molecule of the exact form needed to produce these proteins, and the chances of such a system of molecules arising all together in the right environment must, he argues, be infinitesimal. So it is up to readers of this book to judge how convincingly its authors have put the opposite case.

A. E. SLATER.

Man Into Space. By Hermann Oberth. Weidenfeld and Nicolson, London, 1957. 226 pp. Price 25s.

Apart from a comprehensive mathematical appendix, *Man Into Space* is a purely non-technical exposition of the author's astronautical theories and beliefs. As might be expected, some of these ideas are far-reaching, but while consideration is given to such futuristic conceptions as space settlements and inter-stellar journeys, in the main the book concerns itself with more immediate possibilities and prospects.

Two projects nominated for completion by A.D. 2000 are the establishing of a manned satellite station and the construction of a solar space mirror. Within the next 50 years, too, a landing on the Moon is envisaged, and the difficulties attendant upon lunar surface exploration are to be met with the aid of a self-contained vehicle termed a Moon car, endowed with an ability to leap over 400 ft. wide fissures. The car, which is described in some detail, is conceived as a globular structure, gyroscopically balanced on a single leg, which in turn rests on a driving mechanism, complete with caterpillar tread.

No doubt some of Oberth's proposals will offend the susceptibilities of the sober-minded. But whatever may be thought about his suggested space mirror (diameter 60 miles), or of his cylindrical world (with an internal surface area of some 600,000 acres), few will dispute the timeliness of his call for the immediate development of the ancillary equipment necessary to ensure man's survival in the unknown, e.g., a serviceable space-suit.

P. E. CLEATOR.

Wonderama: a Book of Modern Marvels. By Angela Croome, edited by Eamonn Andrews. Adprint, London 1957.

This book, aimed at readers of 13 and under, contains two sections of particular interest to astronomical and astronautical enthusiasts: "Probing Space", and "Seeing Stars by Radio". They are necessarily brief, but are well written, and the photographs are excellent. The rest of the book deals with other branches of science; the present reviewer found it all most interesting.

G.A.

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